An investigation into the pressures and sensations caused by wearing a bra and the influence of these on bra fitting

By

Xiaomeng Liang, BSc. MSc.

A thesis submitted in accordance with the requirements of De Montfort University for the degree of Doctor of Philosophy

De Montfort University
Art & Design Faculty

May 2008

The candidate confirms that the work submitted is her own and that appropiate credit has been given where reference has been made to the work of others.

Abstract

This thesis is concerned with issues arising from the fit of bras. An investigation was carried out into the pressure and sensations caused by wearing a bra and the influence of these on bra fitting issues. The literature review revealed that there has been only a small amount of research into the topic of the fit of bras, and certainly not enough to effect any marked improvement. There are still many women who are not satisfied with the bra they are wearing, and who, furthermore, find it is difficult to obtain a satisfactory fit, and this especially so in the case of large-sized women. Previous research has shown that pressure is a very important factor in bra fitting, as is also the wearer's perception of the comfort of the bra, and these have a direct bearing on issues of breast health. The whole field of the fitting of bras requires more scientific and technical research.

This study employed survey and experimental research methodology to investigate bra pressure and the sensations influencing bra fitting issues. The investigation revealed that the design of the survey is satisfactory. The use of pressure test equipment, Bra Sensor, and the sensation evaluation method utilizing the Borg CR10 Scale are appropriate. The statistical data analysis methods used to obtain the results were shown to be reliable.

The results obtained from the survey of the wearers' sensations caused by wearing a bra revealed some basic information about the subjects and their bra-wearing habits and a general picture of pressure, discomfort and pain sensations. Further, through an in-depth analysis of the data from the pressure and sensation tests, general characteristics of wearers' sensations in the bra were concluded, the relationships between the pressures and the sensations were established, the factors which influence the sensations were discussed. Analysis was also carried out within the different groups of subjects.

It was discovered, that the same amount of pressure can cause different degrees of sensation in different areas of the bra. The comparison of subjects with exactly the same measured underbust girth, but different overbust girth revealed that their pressure distributions in the bra are similar, but the reported sensations of pressure, discomfort and pain differ. This means for no two subjects were the pressure measurements and their assessments of the sensations the same, especially for the large-sized women. There is some suggestion in the data that women who need larger cup sizes tend to tolerate more pressure and discomfort than those who require smaller cups.

It is considered that the expectations as given in the initial aims have been achieved and that the findings from this study may make a contribution to the issues affecting the correct fitting of bras. For bra designers and bra fitting specialists, the present methods depend mainly on experience, but these results, in contrast, can provide guidance based on scientific methodology. These can explain some of the existing fitting problems, and can be directly used by designers to improve designs and decrease trail and error iterations.

Acknowledgements

I would like to express my deep and sincere gratitude to my supervisors, David Morris, Robert Chen and Jinsong Shen, whose guidance, stimulating suggestions and encouragement helped me throughout the time of my research and writing of this thesis.

I wish to thank the Contour Fashion Department and the TEAM research group of De Montfort University for providing me with equipment and assistance during my research.

Thanks must also go to all the people who were respondents and subjects in my survey and tests. Thank you for your time, patience and cooperation during these processes.

I would like to give my special thanks to David Clubb, for his kindness in proofreading my thesis and supplying useful feedback.

And lastly but by no means least, I extend an enormous thanks to my parents who have always supported and encouraged me in my work, and to my husband Haibo Jia who has been extremely supportive throughout.

Table of Contents

List of Figures

List of Tables

Chapter One
Introduction

1.1 Research questions

Bras have been used for many years and throughout the world to help women obtain support for their breasts and to make their forms look fashionable. The bra could be considered an important, and perhaps essential, undergarment but its history is quite short compared to most other types of underwear. Women wear bras at different times, on different occasions and for different purposes, and therefore, the types of bra are various and versatile, but the most popular style is the underwired bra. The market of bra has risen steadily by some 2-3% each year due to the increase in the total adult female population. Consumers are paying more and more attention to the comfort and fit of their bras.

The benefit of a bra to a woman is obvious; it can provide support, protect the soft tissues and improve the shape of the breasts. However there are also some disadvantages probably caused by the bra, some women think their bra is not comfortable and some regard bras as one of the factors which cause breast pains and diseases. Actually it is not the fault of the bra itself, most of the problems are due to misfitting bras.

The fit of a bra is always regarded as an important aspect of manufacture; it is obvious that no matter how good the material and how well the style is used, it can not be a perfect bra if it does not fit properly. Although the sizing systems of bra manufactures are becoming more and more complicated, — nowadays bra cup sizes run from AA to GG, sometimes up

to L, — most of the systems are based on experience and not on scientific method. Thus the fit of a bra is always a problem puzzling both the manufactures and the women consumers, some of whom, especially the larger-sized women, complain that they can never buy a perfectly-fitting bra from the retailers.

To fit a bra is not easy, due to the anatomy of the breasts. The traditional fitting method is first to use a soft tape measure to measure the rib cage and full bust, and then to calculate the bra size by using a bra size calculation formula, however small variations in the body measurements can cause a difference of up to three cup sizes in the calculated bra size. Therefore, just relying on the calculated bra size is not always enough to give a properly fitting bra, so it is always essential to try on a bra to obtain the proper fit. Some lingerie shops provide a bra fitting service and an experienced expert can help the customer to find a properly-fitting bra. The traditional fitting methods are based on experience of the experts, but it is not always enough to solve all the fitting problems.

There is some research work related to the fit of bras, but not enough to produce much improvement in the situation. A literature review of bra fitting issues shows that research has revealed the following problems which required to be addressed:

(1) A lot of problems still exist in the bra fitting methods; a lot of women are not satisfied with the bras they have and also it is not easy for them to find a perfect fit, especially for those requiring large sizes.
(2) Most bra designers rely mainly on their experience to improve the patterns for their designs as there is seldom scientific and technical research to support their work.
(3) The bra industry pays more attention to the appearance of the bra, but neglects the need to concentrate on the comfort of the bra and on breast health.
(4) There is evidence that there is a link between breast health problems and ill-fitting bras. It is important that a woman's bra fits correctly, both to ensure a flattering shape and to avoid discomfort. Back pain is particularly common amongst large breasted women who wear bras which offer insufficient support. In extreme cases, such discomfort can lead to a woman seeking breast reduction surgery.

(5) The issue of bra fitting still needs more scientific and technical research.

(6) Previous research has shown that pressure is a very important factor in bra fitting. There has been some investigation of the pressure caused by bras on the breasts.

(7) The wearer's perception of the comfort of the bra is also important, and it is directly connected with breast health issues. But there has been little research into the wearer's sensation when wearing a bra.

As described, the fit and comfort of clothing has many associations with a human's sensations of comfort and shape. Recently, psychophysical methods have been introduced into research on the properties of clothing and this opens a new era in this field. It seems that this useful tool may be used to make an improvement in solving some of the existing fitting problems, since the wearer's perceptions and evaluation are the final determinants of the fit of a bra.

Therefore, as a result of the literature review and the existing problems in bra fitting, the research questions addressed by this PhD research project can be presented as follows:

(1) What is the pressure distribution caused by a bra on the breasts?

(2) What kinds of sensations are induced by wearing a bra? May these sensations be evaluated? May psychophysical methods be used to evaluate the sensations?

(3) Does the wearer's bra wearing habits influence the sensations caused by wearing a bra?

(4) What are the relationships between pressure and the sensations?

1.2 The aims and objectives

The main aims and objectives of this research are to conduct a detailed investigation into the pressures and sensations arising from the wearing of a bra and thus provide practical and useful information for improvements in bra design and fitting.

1.3 Research methodology

In accordance with the research questions and the aims and objectives, the research methodologies employed are as follows:

(1) Literature review: Carry out a comprehensive literature review of relevant sources by searching journals and internet websites, interviewing companies and research institutions and collect the existing information which is chiefly concerned with bra fitting issues.

(2) Survey: Carry out a bra survey of the wearers; explore their basic knowledge about bra wearing and the pressures and sensations caused by wearing a bra.

(3) Experiments: Carry out the bra pressure tests to measure the pressure and the wearer's sensations caused by wearing a bra.

(4) Data analysis: Analyse the data from the survey and experiments. The findings may be helpful to solve some of the problems in the fit of bras.

Chapter Two
Literature review

2.1 An Introduction to women's bra

2.1.1 The history of the bra

Throughout history women have used various garments designed to support, protect, restrain and shape their breasts, and these can be traced back to as early as 2500 to 2000 BC. From the 1500s until the 1900s the corset was the most popular and most important undergarment used by women for the purpose of shaping the waist and lifting the breasts.

The bra was born in 1904, it was a lightweight undergarment made of silk and embroidered with lace. The inventor, one Charles De Bevoise, was a successful corset-maker and he called his creation a 'brassiere'. The commonly-accepted first and modern brassiere to receive a patent was invented in 1913 by a New York socialite named Mary Phelps Jacob, who sewed two silk handkerchiefs and some pink ribbon together, thus designing an alternative to the corset. After that, the corset's reign began to collapse, and the new era of the bra was started (Pedersen, 2004).

In the 1920s and 1930s, women began to discard their corsets in favour of bras for the bra was designed as a tight band which can make the body look slim. There are also some great improvements in bra design that occurred in this period. By 1928, the entrepreneur Ida

Rosenthal introduced cup sizes and bras for all stages of a women's life; in 1935, Warners improved the cup design and the sizing system to give a better individual fit. In the 1940s and 1950s, the popularity of the bra increased and bra development continued; most of bras of this period were made of cotton and elastic. During these decades, the first padded bra, the first 'falsies' and the first bikini were introduced, the underwired bras were developed and big breasts became fashionable. In the 1960s and 1970s, bra fashions were a reflection of general fashion trends and a variety of bra styles emerged, new synthetic materials were introduced and, most importantly, women were concerned not only with the appearance of the bra, but also began to pay much more attention to the comfort factor. For the bra industry, the 1980s and 1990s were most exciting, there was constant innovation, during the technology boom of the 1990s, bras were even designed to contain heart monitors, global positioning system locators, cellular phones, and cancer warning sensors. In the new millennium, today's bras embody function, comfort, intelligence, personality and fun, and manufacturers are constantly working to improve the design (Bellis, 2006; Hawthorne, 1992; Pedersen, 2004; Bookrags, 2006; The Breast Site, 2006; Wikipedia, 2006).

2.1.2 Bra classification

A bra consists of cups for the breasts, a center panel, and a band running around the body under the bust and, unless it is a strapless bra, it will also have a shoulder strap at each side. It is typically made of a fabric such as cotton or lace, with the cups for the breasts given shape by underwires or plastic reinforcements. The bra is usually fastened with a hook fastener on the band, typically at the back, but in some bras the fastener is situated at the front, in between the cups. Some bras contain padding, designed to improve comfort and provide a more flattering shape — this is sometimes in the form of silicone gel packs. Push up bras, designed to enhance cleavage, usually contain padding. Breast pads or "falsies" are sometimes worn within the bra to give the appearance of larger breasts — this requires the wearer to wear a larger size of bra than actually required by her breasts.

Bras can be classified into different groups namely by type and use, by production method and by pattern and style. These classifications have been used in the previous research (Wikipedia, 2006; The Breast Site, 2006; Lane Bryant, 2006; Figleaves, 2006; Bare Necessities, 2006; Onehanesplace, 2006).

2.1.2.1 By type and use

Women wear bras at different times, on different occasions and for different purposes. Using this system, bras are classified as in Table 2.1. The photos come from Amazon (2006), Figleaves (2006), Sporteze (2006) and Bemis (2006).

Table 2.1 Bra classification by type and use

Classify	Description	Picture
Full support bra	This is a type of bra designed to offer good support for the whole of both breasts, and as such is a typical, practical bra for everyday wear. Full-support bras provide lift and support via clever design details: seamed cups with banded edges, hidden under-cup slings, wide side wings, plus two- or three-hook closures. They may be either wire-free or underwired.	
Light support bra	A light-support bra is designed for small sized women who wear a bra size between 32 and 36, with cup sizes AA, A, or B. Many light-support bras are unlined and wire-free, with seamless cups, bandless edges, and cutaway wings. These bras provide shaping plus minimal support.	

Padded bra	This is a simple bra with padding added inside the lining. It is designed to provide a fuller shape for small breasts and an alternative to bra stuffing, a practice among preteen and teen girls in which tissues, cotton balls, or socks are placed inside a bra to simulate larger breasts. Unlike push-up bras, however, most padded bras support the breasts but do not significantly lift them. The lower cups of this bra style are filled with graduated padding that achieves a natural looking roundness and an enhanced cleavage. Padded bras have some type of padding lining the cups. Graduated padding is thicker at the base of the cups and creates a natural looking silhouette as well as the appearance of increased cleavage. So they are ideal for women who would like to enhance their breasts.	
Push up bra	This style is structured so that the breasts are lifted and the cleavage emphasised. A good push-up bra will give a fuller looking bust and enhanced cleavage, with or without the help of padding. It creates the appearance of increased cleavage using cleverly angled cups (which generally have underwires). Many push-up bras contain padding, typically made of foam or rubber, but some contain pads filled with water, an oil/water mixture, or gel. Sometimes they have small removable pads--called cookies--for extra volume.	
Plunge bra	A Plunge bra creates the appearance of increased cleavage because of its deep (plunging) front silhouette, angled cups and thin centre gore, and usually with an underwire. It is not the same thing as a push-up bra (although push up bras are often plunge styles), a plunge bra is distinguished by the part of the band that joins the cups - if the band is below nipple level, then it is plunge. This style is very good under low-cut tops.	

Strapless bra	A strapless bra is designed to have no shoulder straps for wearing with clothes that reveal the shoulders, such as halterneck tops. Today's strapless bras stay up better than ever, and also give very good support, thanks to design details such as padding, boning, and shaping panels. Many strapless bras come with detachable straps for multiple wearing options.	
Sports bra	A sports bra is designed to keep the breasts under control when undertaking any physical activity. Sports bras provide support, motion control and a snug fit during workouts. They are more sturdy in their construction than regular bras, and offer greater support for the chest, thus increasing comfort and reducing the chance of damage to the ligaments of the chest during high impact exercises such as jogging. They are usually made of a stretchable, absorbent fabric such as Lycra, and may be designed to draw perspiration away from the skin to reduce irritation and keep cool and dry. Many women, particularly those with large breasts, find sports bras essential for exercise, as bouncing breasts can cause pain and discomfort, as well as embarrassment. Some sports bras are meant to be worn as outerwear. The sport bra is often designed with no underwire, hardware, hooks or zippers to chafe. It often has a high racer back for added support.	
T-shirt bra:	It is made of thin fabrics, designed to appear invisible under even the thinnest fabrics, so that a tight t-shirt may be worn without the bra being visible. T-shirt bras are usually seamless, generally made of microfiber with contour cups, so they are smooth under clingy clothes. Also they are either lined with sleek foam or lightly padded with polyfill, so which block embarrassing show-through.	

Self-adhesive bra	Revealing eveningwear calls for the latest self-adhesive solution. The self-adhesive bra is designed as a stick-on backless and strapless bra, and uses petal tops to prevent the dreaded protruding nipples.	
Multiway bra	With a multiway bra, the straps can be worn in a variety of ways: over the shoulders as normal; as a halterneck; crossed around the middle of the body (for backless styles); or even removed altogether. So, it may be worn as follows: strapless, regular, halterneck, one shoulder, racerback and low back.	
Minimizer bra	The minimizer bra is designed for large-breasted women to diminish the outline of the bust, reducing the bust-line by up to one cup size or even more. By compressing and shaping the breasts, it gently redistributes tissue to shape and streamline curves with the result that clothes fit and feel better. A good minimiser will redistribute the breast tissue (usually to the sides) without the underwiring digging into it.	

Built-in bra	A built-in bra is a supportive brassiere, like structure on the inside of another garment, such as a swimsuit, camisole or tank top, which provides support for the bust without the need for a separate bra. In most such garments, these bras consist of a horizontal elasticated fabric strip, although some do have cups and underwires as with other bra types.	
Mastectomy bra	A mastectomy bra is designed with pockets in the cup area to hold breast prosthesis, so that prosthesis may be held in place, and is intended for women who have lost one or both breasts in mastectomy treatment for breast cancer. There is a wide range of styles and colors of mastectomy bras and more and more are being added to the market all the time. Design and fit improvements are being made constantly. The silicone breast prosthesis simulates the natural breast in its shape and weight. The main advantage of prosthesis is to provide symmetry and balance to a breast cancer survivor's body. Getting the right prosthesis is fundamentally important to eventual comfort level. A well fitting prosthesis and a well-designed and fitted mastectomy bra will help to balance the posture and provide protection for the chest and breast cancer scars. As well, it will reduce the chances of back problems and shoulder and neck pain. Further pre-surgery clothes will continue to fit well.	

Maternity bra	A maternity bra is designed so that it can be expanded to adjust as the breasts increase in size over the course of a pregnancy and supports daily breast growth. It is slightly different from nursing bras though the terms are sometimes used interchangeably. A maternity bra is made from comfortable and softer fabrics such as cotton to pamper tender tissue. The cups usually stretch to accommodate the changes in breast size.	
Nursing bra	Distinguished by drop down cups that can be opened easily (preferably with one hand in the middle of the night), nursing bras are essential for breastfeeding mothers. It is designed to help make breastfeeding simpler by allowing for easy access to the nipples. Traditionally, nursing bras are made with flaps of fabric over the cups which can be unclasped and pulled down to access the breast. Even with the "flap" pulled down, the cup of the bra supports the breast. There are also no-flap versions made of stretchable fabric which can pulled to the side when it is feeding time. Underwire versions of nursing bras are discouraged because they can constrict the breast and can cause either blocked ducts or mastitis though underwire versions are readily available.	

2.1.2.2 By production method

Using this scheme, bras may be classified as in Table 2.2. The photos come from Amazon (2006), Figleaves (2006), Sporteze (2006) and Bemis (2006).

Table 2.2 Bra classification by production method

Classify	Description	Picture
Seamed bra (cut & sew bra)	This is the traditional method of producing a bra. A seamed bra is highly constructed, with two-section or three-section cups. The cup sections are sewn together (seamed). The more seams, the greater the support.	
Seamless bra	This is a bra constructed without seamed cups. Many seamless bras have clever details designed to add support--such as special linings and hidden under-cup slings. There may be seams in other parts of the bra and it may still be considered seamless. Seamless bras are very suitable for pairing with clingy knits and lightweight jerseys since they are virtually invisible under clothing. This style of bra shapes and slims the bust so that clothes fit better.	
Seam-Free bra	A seam-free bra is seamless all over, not just in the cups. The only seams appear where the bra straps attach to the bra. Seam-free bras feel blissfully soft and look super-smooth under clothes. It is made of a special fabric and knitted in one seamless piece on a circular knitting machine.	

Moulded bra	Machine moulded fabric is used to mirror the breasts for a natural shape, enhanced comfort and smooth look. A moulded bra has seamless cups which are machined moulded to fit the shape of the breast. It is generally unlined and may be either soft cup or underwire. The cups are rigid enough to keep their shape when the bra is not being worn, but it is flexible enough to give a natural look.	

2.1.2.3 By pattern and style

Again, a bra may be classified by its pattern and style as in Table 2.3. The photos come from Amazon (2006), Figleaves (2006), Sporteze (2006) and Bemis (2006).

Table 2.3 Bra classification by pattern and style

Classify	Description	Picture
Underwired bra	The underwired bra is a bra with a rigid support sewn into a cushion under the cups, comfortably maintaining the curves of the bust, designed to provide additional lift. The flexible wires inside the bottom of the cups provide lift and support for a shapely, sag-free look. Usually they are plush-backed or cushion-tipped to help assure no-poke comfort. Most underwiried bras offer moderate to full support. Underwiring can be found in many different styles of bras. Some women swear by their underwires and others find them very uncomfortable.	

No wire soft bra	A no-wire soft bra has no underwires, which can mean greater comfort, and is especially comfortable for everyday wear. It feels more like an undershirt; stretch cups move with the breasts and achieve an attractive, natural look. It can also be padded or lined. Today many no-wire bras also offer excellent support, due to clever design details: criss-cross frames; inner under-cup slings; 2-ply, moulded, lined, or padded cups. Some no-wire bras give light to moderate support, for petite to average figures. Others furnish full support.	
Balcony bra	A balcony bra is of half cup construction, giving a push-up effect with wide-set straps and horizontal bust line, open on top and enhanced uplift and cleavage. Straps are generally farther apart, creating a square neckline. It is very fashionable and often seamed or boned, It is a member of the push-up family, but not all push-ups are balconettes.	
Push up bra	As described in 2.1.2.1	

Plunge bra	As described in 2.1.2.1	
Strapless bra	As described in 2.1.2.1	
Moulded bra	As described in 2.1.2.2	

T-shirt bra:	As described in 2.1.2.1	
Front close bra (Front hook bra)	Most bras fasten in the back, usually with hooks and eyes, but front-close bras fasten in front with either hooks or clasps. This is the easiest style to put on and take off; It is also adjustable at the back for a comfortable, custom fit. It is great for women with arthritis, and ideal with low-cut tops.	

2.1.3 Bra size

Bra sizing systems differ widely between countries, and also between companies. Some countries (e.g. Asian countries) use the metric measurement system rather than the imperial system used in the UK or the US customary system used in the US. When the metric system is used, sizes usually correspond as, for example, 32 in imperial is a 70 in metric, 34 in imperial is a 75 in metric, and so on and so forth. Australia uses dress size instead of band size (Wikipedia, 2006).

The bra sizing system currently used in the UK is a traditional commercial method which is calculated using an imperial measurements. This system was devised to relate to dress sizes (Morris, 2004a).

The bra size is calculated from 2 separate body measurements: rib cage (which determines the band or back size) and full bust measurement (which determines the cup size).

The rib cage measurement is taken immediately below the breast, measured tightly around the torso, directly underneath the breasts. The underband measurement plus 4" if it is an even number and 5" if odd, gives the band or back size. A conventional dress size 12 women would have a 29 or 30 inches underband measurement, so adding 4 or 5 inches to this measurement produces the 34 bust size of the size 12.

The full bust measurement is taken around the chest including the fullest part of the breasts over the nipples, while standing straight with arms to the side. The cup size is determined by the difference between the band size and the full bust measurement. The cup size relates to an alphabetic sequence A, B, C, D etc. A is a small cup size, D is larger. The formula is shown in Table 2.4.

Table 2.4 Cup size formula

Full bust measurement minus band size (inches)	Cup size
<0"	AA
0"	A
1"	B
2"	C
3"	D
etc	etc

The sizing of cup sizes can be confusing, since some manufacturers use multiple letters such as AAA or FF. A common cup size system amongst European manufacturers, in order of increasing size, is: AA-A-B-C-D-DD-E-F-FF-G-GG-H-J. It is important to note that the actual size of bra cup varies with band size. As an example, the cup in a 34B bra is smaller than the cup used in a 38B.

Bra size grading is another important aspect in the bra sizing system. The current bra grading system used in manufacturing is largely based on a system called 'cross grading'. The essence of this system is that the complete front of the bra has a relationship to other bra sizes. For example, the cup and cradle size is the same within 34B, 36A and 32C (The cradle is the banding underneath the cups).

Besides the traditional English method of determining bra size, there are some other ways of calculation. In the United States, various manufacturers and boutiques recommend adding a different number to the measured circumference to determine band size, generally some 4 to 6 inches. A further complication is that some manufacturers say that when the rib cage measurement is 35" (89 cm) or more, only 3" (7.5 cm) should be added to determine the band size. Still others, particularly stores that specialize in specialty sizes, do not recommend adding anything to the size, as the band is meant to fit around the area measured, not higher (Bra size.org, 2006).

Using a graphical mathematical model, Wright (2002) analysed the widely used traditional procedure for calculating bra size from body measurements, and pointed out that arbitrary small variations in the body measurements can cause a difference of up to three cup sizes in the calculated bra size, and suggested an improved procedure.

Any system for determining bra size is not without its problems, and the only real way to get the right size is by trial and error or, more effectively, to visit a certified bra-fitting specialist, usually to be found in better quality stores. Unfortunately, as is the case with most clothing, not all bras are made alike, and women find that the fit of a bra differs from manufacturer to manufactures.

2.1.4 The market for bras

The Mintel Underwear Retailing Report (2006) and The Bra and Pant Report (2005a) for the UK describe the current state of the market for bras in the UK.

2.1.4.1 Growth in the market

The market for bras and pants has risen year by year, and is estimated to stand at £1,174 million in 2005, having increased by 27% in the previous five years and by some 7% since 2003. It now accounts for almost half (49%) of the total underwear market, which grew by 14% over the previous five years. Sales of bras have been particularly strong, growing by 8% in the last two years, compared to a 5% rise in sales of pants. The increasing sales are shown in Table 2.5.

Table 2.5 UK retail sales of underwear, by value, 2000-05

	All underwear		Bras and pants		Bras/pants as % underwear
	£m	Index	£m	Index	
2000	2,100	100	925	100	44.0
2001	2,150	103	970	105	45.1
2002	2,225	106	1,040	112	46.7
2003	2,274	108	1,095	118	48.2
2004	2,330	111	1,135	123	48.7
2005	2,395	114	1,174	127	49.0

The market is split some 67/33%, with the value of the sales of bras being £786 million in 2005 and that of pants being £388 million. Put in a different context, the spending on bras and pants for every female in the UK, aged 15 and over, is £46.20 per year.

Between 2000 and 2005, the sales of bras grew by 36% at current prices, equating to 60% at constant 2000 prices. Underwired bras continue to dominate the market, with more than two-thirds of sales, followed by soft bras which account for nearly a quarter of sales. Sales

in both the underwired and the sports combined maternity categories have grown by around 10% in the two years to 2005, while sales of soft bras have remained stable, at £189 million.

2.1.4.2 Underwired underpins the market

The market for bras divides into three main segments; underwired, soft, and sports and maternity.

Table 2.6 UK retail sales of bras, by style and value for 2003 and 2005

	2003		2005		% change 2003-05
	£m	%	£m	%	
Underwired	493	68	550	70	+12
Soft bras	189	26	189	24	-
Sports and maternity	43	6	47	6	+9
Total	725	100	786	100	+8

Table 2.6 shows that underwired bras account for the majority of value sales, with around 70% of the market. Soft bras represent around one quarter (24%) of sales and sports and maternity bras have a minor share of 6%.

Sales of underwired bras have fared particularly well, growing by about 12% to an estimated £550 million lasting the two years to 2005. Fashions in outerwear as well as growth in the average British bust size over the last ten years from 34B to 36C or D have favoured the underwired segment of the market.

2.1.4.3 An encouraging rate of growth

The market seems set to enjoy steady, continuous growth in the future, increasing by 2-3% each year. The projected increase in the total adult female population will ensure the demand for underwear purchases continues. Sales will be further supported by the growth

in the number of younger consumers, especially the 15-24-year-olds, who are more fashion driven and more frequent purchasers of premium lines compare to older age groups. Increases in employment levels will also play an important role in future market growth.

The need for increasingly larger cup sizes is seen as a major factor for increased demand. Nearly 50% of the market is now for D+ fittings and there is a notable trend for bras with small backs and big busts such as 30/32 E and F. These are young women who want fashionable and pretty bras; they may be that shape naturally, or because of enlargement operations. Other areas highlighted for growth are the teen and sports sectors, both for brands and for own-brand retailers.

2.1.4.4 Comfort and fit are key purchase drivers

Nearly half of all consumers say the attributes of comfort and fit are more important than style when buying underwear and hosiery, and these purchasers are likely to be 35 and over. Therefore retailers highlighting these factors in their ranges will likely attract customers. However, the retailers could also emphasise the 'feel good factor' because over a quarter of customers think that wearing nice underwear makes them feel good, and this may also encourage the replacement-only purchasers to buy more often, for want and not just need.

Consumers are sensitive to price differences but more so for briefs and multi-packs than for bras where there is a fashion and fit issue. There is very little price sensitivity in the larger-size market and also for upper mainstream brands that offer real innovation and fashion differentiation but also good value, for example, the Elle Macpherson brand that is both fashionable and not too expensive.

2.2 Bra fitting issues

2.2.1 Background: breast anatomy, physiology and health

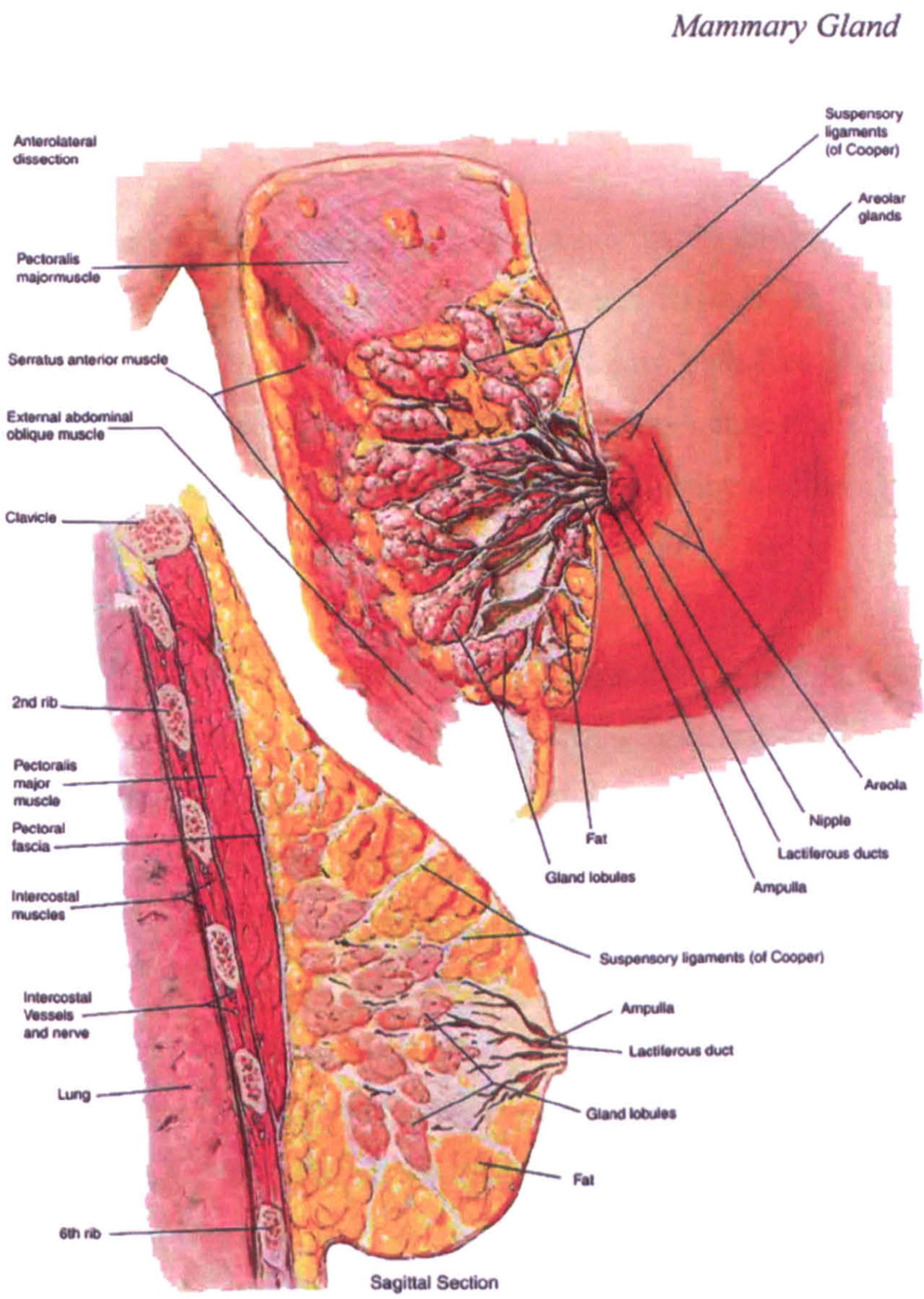


Figure 2.1 breast anatomy

Each breast is 90% water, can weigh 200-800 grams, and the anatomy is shown in Figure 2.1(Utexas, 2006). They are supported by and attached to the front of the chest wall

between the 2nd and 6th rib on either side of the breast bone, or sternum, by ligaments. They rest on the major chest muscle, the pectoralis major. The breast has no muscle tissue. A layer of fat surrounds the glands and extends throughout the breast (Morris, 2004b, 2004c, 2004d, 2004e; Seer's training web site, 2006).

Each breast contains 15 to 20 lobes arranged in a circular fashion. The fat (subcutaneous adipose tissue) that covers the lobes gives the breast its size and shape. Each lobe is comprised of many lobules, at the end of which are tiny bulb like glands, or sacs, where milk is produced in response to hormonal signals. Ducts connect the lobes, lobules, and glands in nursing mothers. These ducts deliver milk to openings in the nipple. The areola is the darker-pigmented area around the nipple.

The breasts of an adult woman are milk-producing, tear-shaped glands; they are hormonally active and change in shape and weight regularly during each month. They have no internal support structure and rely totally on skin tension and genetic characteristics for their shape. As many pairs in human anatomy, such as the feet or the hands, they are often asymmetric and the left breast statistically larger (up to 2 cup sizes) than the right.

Komotv divides breast health problems into three types: non-disease breast discomfort, benign breast disease and breast cancer. Breast pain (mastalgia), a kind of breast discomfort, is the most common breast related complaint among women; nearly 70% of women experience breast pain at some point in their lives. Breast pain may occur in one or both breasts or in the underarm (axilla) region of the body. The severity of breast pain varies from woman to woman; approximately 15% of women require treatment (Imaginis, 2006). Benign breast disease refers to a group of breast diseases in which lumps or mammographically-detected abnormalities have been biopsied and found to not contain cancerous cells. Benign breast conditions are very common and are usually not life-threatening, although, rarely, some benign conditions are associated with a later risk of developing breast cancer (Mayo Clinic, 2005). Breast cancer is a malignant cell growth in the breast and if left untreated, the cancer spreads to other areas of the body. Breast cancer

is the most common cancer in women. There are several types of breast cancer, but the common types are ductal carcinoma (occurring in 85 to 90 percent of the cases) and lobular carcinoma (occurring in about 8 percent of the cases). Ductal carcinoma arises in the ducts (a tubelike passage leading from the lobes, lobules and bulbs). Lobular carcinoma arises in the lobules (part of the lobe which ends in dozens of tiny bulbs that can produce milk). If the cancer spreads outside the breast it is called metastatic breast cancer (Komotv, 2006).

2.2.2 The importance of bra fitting and the traditional bra fitting methods

The bra may be considered as an important, and perhaps, essential, undergarment for women. Firstly, the bra can provide a fashionable shape to the breast, and especially when the breasts have started to sag, the bra can lift the loose soft tissue and provide a fashionable, upright look. Wearing a bra will not prevent the breasts from sagging as nature has predetermined that, but a good bra can help prevent a whole raft of discomfort issues, both physical and mental. Secondly, the breasts need the support of a bra, especially for the large sized women because large unsupported breasts can cause breast and back pain. Yet other benefits of the bra are to provide support when active; to reduce up and down movements of the breasts during exercise, to protect the soft tissue and to give the wearer a feeling of comfort.

There has been some research to investigate if there is a link between the wearing of a bra and breast health problems. Singers (2005) studied 4,500 women, asking about their habits in purchasing and wearing bras. Without taking into account other lifestyle factors, he found that the more hours per day that a bra is worn, the higher the rate of breast cancer; those women who do not wear bras have a dramatically reduced rate of breast cancer. Hsieh and Trichopoulos (1991) published an article on breast cancer risk, and as a side issue in their paper, they mentioned that Premenopausal women who do not wear bras had half the risk of breast cancer compared with bra users, possibly because they are thinner and likely to have smaller breasts. Among bra users, the need for a larger cup size was associated with an increased risk of breast cancer, although the association was found only among

postmenopausal women and was accounted for, in part, by obesity. These data suggest that the size of the breast (and conceivably mammary gland size) may be a risk factor for breast cancer.

At moment, there is no firm evidence for and explanation of a link between wearing a bra and breast cancer, but compression of the breast tissue can cause poor lymphatic drainage, and failure to breast feed, whilst, resultant bruising of the breasts may increase cancer risk. There are a range of breast health problems that are caused by badly fitted bras including mastalgia, lumpy breasts, intertigo, poor lymphatic drainage and failure to breast feed. It is possible that wearing an ill-fitting bra is a factor that could explain many breast health problems, and it seems to be a reasonable conclusion that wearing a properly fitted bra is important not only for providing a pretty upper body figure, but even more so for breast health.

Every woman's breast volume and shape is as unique as their fingerprint, and breast size will also change over time and due to daily hormonal activity. It has been reported that one in three women complain that they cannot find garments which fit correctly, and one in two women are wearing the wrong sized bra (Probe, 2005). That it seems not to be easy to find a perfect fit in a bra, but the search for a good fit is very important.

The first step in fitting a bra is to find out the size, as previously described, by measurement and then calculation of the bra size. But small variations in body measurements can cause a difference of up to three cup sizes in the calculated bra size. Therefore, relying on the calculated bra size is usually not enough to ensure a properly fitting bra. So a second step is to use some empirical methods to correct the bra size.

Some lingerie shops can provide a bra fitting service, where an experienced expert can help the wearer to find a properly fitted bra. The following are the traditional bra fitting methods, together with some guidance on their use (Morris, 2004b, 2004c, 2004d, 2004e; Herroom, 2006).

(1) Band fit: The back and front of bra band should be level and parallel to the floor when the wearer is viewed from the side in a mirror. If the band is too tight, digs into the flesh or is simply uncomfortable, the bra is too small. Signs that the band size is too big include the breasts falling out from the bottom of the bra and the bra riding up at the back. A correctly sized band will fit firmly around the body and not ride up at the back. A new bra should be able to pass this test with the clasp on the loosest fitting - this allows the wearer to tighten the bra as it stretches with wear and washing. The customer should try to avoid buying a bra where the best fit is at the bra's tightest setting, but rather buy one at its loosest, or at least its middle, fastening position.

(2) Cup fit: The bra cups should be large enough to prevent breast tissue from bulging or spilling out over the neckline or armhole edges. It should be noted whether the bra cups are too large, if they have wrinkling, or if they are clearly larger than both of the breasts.

(3) Underwires: The breasts have a natural "crease line" where the underwire should fit comfortably against the ribcage. The diameter of the underwire is too small if the underarm end is poking into the breast tissue, or, if it catches the arm as it moves forward. The diameter of the underwire is too large if the underarm end is poking into the armpit. The best underwire size for the wearer is one that encircles the breast, giving a more rounded and defined look.

(4) Center Panel: It is preferable that the centre panel, between the cups of the bra, sits firmly against the chest (sternum), but, there are some exceptions. For fitting wire-free (soft cup) bras and in the case of women with fuller breasts close together, it may not be able to achieve a fit where the panel touches the sternum. This does not indicate a poor fit.

(5) Straps: The shoulder straps on a bra should rest flat on the shoulders. They should not cause dents nor fall off the shoulders. Shoulder straps are designed to carry minimal breast weight. If there are dents across the shoulders from the straps, then the straps are stressed too hard, a smaller band size is probably needed to give the bra more support. If the straps keep slipping, there are several possible causes. The problem may be that the placement of the straps on the bra is too wide. Wide-set straps are a popular look at

present and are common on push-up bras because wide-set straps tend to push breast tissue inward to maximize cleavage. If the wearer is wearing a push up bra and has this problem, it will necessary to find another style. If the cup size is too large, there will not be enough breast tissue to fill out the top of the cup and this will cause the straps to slide down from the shoulders. The straps could also be sewn too far apart on the back of the bra. To stop the straps from falling, the customer should consider a bra with the straps sewn in front directly above the apex of the breasts, and with leotard or racerback styling at the back.

(6) The customer should then finally try on a top or dress to check the overall effect.

The following points should be considered in individual cases.

(1) For most women, one breast is larger than the other. In many cases one breast may even be one cup size larger than the other. In such situations, a cup size should be chosen that fits the larger breast. The smaller breast may then be supplemented with padding. Alternatively, a moulded cup bra will hide the fact and make both sides look the same in size.

(2) As the band size of a bra increases, so does the actual cup size. Therefore a D cup in a 38D is going to be smaller than a D cup in a 42D. For example, if the band is too small, but the cup fits well, go from a 38D to a 40C to obtain a similar cup size.

(3) If the wearer has a small back, buy a bra that fits in the cups, and then have the bra altered to remove the excess at the back and/or sides.

(4) If the wearer has a broad back, buy a bra that fits in the cups, and then purchase an extender to increase the size of the back of the bra.

(5) Big busted women, after fastening a bra, should lift up their arms to see if any breast tissue falls out from under the bottom of the cup. If this happens, the cup size is probably too small.

(6) Like new shoes, a new bra will probably be a little tight at first. As the spandex relaxes, the bra will become a little looser on the body. This is the reason why a bra should be rested for a day between wearing, giving the bra a chance to return to its relaxed shape, and also giving time to air.

After the above steps have been gone through, a properly fitting bra should satisfy all the items in the following checklist.

(1) Smooth fitting cups.

(2) The centre panel lies flat against the breastbone.

(3) The bottom of the bra at the front and back is parallel to the floor or slightly lower at the back.

(4) The straps should be correctly tensioned, and not dig into the shoulders.

(5) The cup fabric should be stable enough to give support as well as a good breast shape.

(6) An underwire should sit correctly against the rib cage, and encircle the breast without poking, protruding or pinching.

(7) Good breast uplift so that the apex of the breasts is mid-way between the shoulders and the elbows.

(8) Breasts face the front and do not sag or fall to the sides. This breast position allows the wearer to swing the arms freely.

(9) A finger can be run under the front band. The bra should be snug, but not too tight.

(10) Does it feel comfortable when sitting? The ribcages tend to expand when seated. If there is any doubt that the band is large enough, this quick test will provide the answer.

(11) The bra should still sit securely when the body is moving.

(12) If there is still not a perfect fit, an alteration should be considered.

2.2.3 Recent research and existing problems in bra fitting issues

Although the existing bra fitting methods used in the bra manufacture and in lingerie shops are reasonably satisfied, researchers are trying to explore the problems of bra fitting and to develop the new methods.

A survey carried out in Japan by Schlomski (2001) showed that 49% of the women questioned were either unsatisfied or only slightly satisfied with the fit of their foundation garments, and more than 52% of them had real problems with finding their correct size.

Women in Japan have become taller and their bust measurements have increased in size and, since the last body measurements survey was taken in 1983, the proportion of women wearing a 'C' cup has increased from 8.5% to 20.2%. As part of a research project, 1500 woman were measured using 3-D scanner technology, and the measurements were evaluated with the aim of developing an optimum design for foundation wear.

It is estimated that almost 70% of Australian women are currently wearing the wrong-size bra. Using a professional in-store fitter is no guarantee of getting a well-fitting one either. A covert investigation by a consumer group has found that a large majority of bras chosen by professional fitters were a poor fit, with 43% too small (University of Wollongong, 2005).

Greenbaum et al (2003), who are plastic surgeons, suspected that women seeking reduction mammaplasty often wear ill-fitting bras, which may exacerbate some of their symptoms. Therefore, they investigated 103 women who attended a nurse-run pre-assessment clinic, and found out of the 102 women suitable for inclusion in this study, all wore the wrong size bra. This study gave an indication that bra fitting is a real problem for women, and it needs more research and the application of advanced technology.

From the above research, it may be seen that there are problems exist in the traditional bra fitting methods. Firstly, the bra sizing method is not accurate enough to let women choose the right size. It is also impossible for everyone to have a fitting from a professional fitter. Secondly the traditional fitting methods tend to pay most attention to the appearance of the bra, and sometimes, a pretty figure means a good fit. But actually, what is more important is the comfort of the bra, because an ill-fitting bra can result in breast health problems. Again, it is also not enough to have a fitting from a professional fitter because the fitter may be pressured by the retailer to suggest one brand rather than others even though it may not be a better fit for the wearer. On the other hand, the consumers are also easily influenced by the fitters' opinion, and suppress their own opinion of the bra. Thus in addition to research into breast health and bra sizes, there are also research projects investigating the properties of bras and methods to improve both the fit and fitting of bras.

In order to obtain basic data for designing good-fitting bra, Okabe et al (2003) analysed the vibration characteristics of the breasts in 7 females. It was found that the frequency of breast vibration had a strong correlation with the frequency of steps; the amplitude of breast vibration was greater during running than walking, and greater along the vertical axis than along the horizontal axis. This research provided some basic data about the movement of the breast, and this information may be used to improve bra design and fitting.

Pechter (1998) stated that the current popular system of determining bra size is so inaccurate as to be useless. Add to this the many different styles of bras and the lack of standardization between brands, and it maybe seen why finding a comfortable, well-fitting bra is more a matter of educated guesswork and trial and error than of precise measurements. An improved method of determining cup size by measuring directly the circumference of the breast was developed in Pechter's research. If adopted commercially, this simple method could reduce dramatically the number of women said to be wearing the 'wrong-sized bra'.

Australian scientists are carrying out research on how breast structure relates to motion and potential tissue damage, and developing a bra made of 'intelligent fabrics', which will change its properties in response to breast movement, giving better support to active women when they need it most. It will be the first time intelligent polymer systems have been completely integrated into fabric structure. (University of Wollongong, 2000; ABC Science, 2000; Smh.com.au, 2002)

Salt (2003) employed another method, investigating a modelling process to capture breast shape and convert the data into an improved bra pattern.

Studies have confirmed that many women, particularly larger-busted women, experience breast discomfort while exercising, causing some to avoid exercise altogether. In order to improve the fit of bras for large-sized women, Krenzer et al (2005) used a systematic

design process incorporating conducting several research studies as input for the development of a prototype sports bra for large-busted women. The resulting prototype sports bra, developed by draping and flat pattern, was designed to resolve specific comfort, support, and aesthetic issues reported by large-busted women.

Shimizu and colleagues (1993) studied the pressure of the bra on the body statically and dynamically, and found that the bra pressure at a certain point was different when a different movement was performed.

Li et al (2003) investigated the pressure caused on the breasts by wearing a bra. Based on the analysis of the biomechanical characteristics of the human body, a 3D biomechanical model of a female body, which consists of an elastic breast and rigid body was presented.

The above research projects have progressed studies in bra fitting issues, and have also revealed that pressure is a very important factor in bra fitting, so that more research needs to be concentrated in this area.

2.3 Pressure and discomfort properties of garments

2.3.1 The relevant literature on pressure and comfort properties

The effects of pressure on the human surface layer has received considerable attention over the years since it can cause injury, pain, discomfort, and/or possibly even improve comfort. When we wear clothes, shoes, neckties, sleep on a bed, sit on a chair, use a headset, use hand tools during manual work, or use arm rests or elbow supports to reduce muscle fatigue, the forces from these external sources/implements exerted on the body are quite varied, but in all cases act on limited areas (Goonetilleke, 1998). Even though forces on the human body are unavoidable, comfort in many cases appears to be obscure and certainly not guaranteed. Comfort encompasses many different characteristics and has varied definitions:

for example, it has been defined as a lack of discomfort (Hertzberg, 1972) and more recently it has been associated with feelings of relaxation and well-being (Zhang et al., 1996). As described above, the pressure and comfort properties play the important role in bra fitting issues, thus, some current research related to the pressure and comfort properties of clothing are summarised below.

Nakahashi et al (1999, 2000) conducted experiments on the differential thresholds for pressure on the front and back parts of the lower leg, on the compressive feeling of trial stockings and to clarify the comfortable and critical clothing pressure values on the thigh, calf and ankle. It was found the comfort threshold of pressure on the front part of a lower leg was lower than that on the back; compressive feeling was more influenced by pressure on the front part of a lower leg than that on the back. The data of mean values of a comfortable clothing pressure and the critical clothing pressure on the thigh, calf and ankle were obtained. It was discovered different women preferred a high clothing pressure on different areas of the leg. This result may be used to find guides for designing pantyhose with a comfortable support force on legs.

Chen and Zhao (2003) used dummies designed for resuscitation practice to obtain basic data on clothing pressure. In order to investigate the comfort of men's suit when worn, an analysis is required of basic data on the comfort of wearing a suit. However, in such an investigation, it is difficult to find ideal persons as test subjects. In these experiments, dummies designed for resuscitation practice were used to obtain the clothing pressure in both the normal standing posture and in patterns of movement, and these data were compared with that from human subjects' to give the relationship of the pressures between the dummy and human. It was found that all the patterns of dummy used have certain limitations when used for clothing pressure measurements. It was further shown that, when using a dummy, instead of a human subject, to investigate clothing pressure in both normal standing postures and movement patterns, not only the dummy's features such as surface hardness, form and size, but also postures needed to be taken into consideration.

Makabe et al (1991) carried out sensory tests and measurements of clothing pressure on subjects wearing brassiere and girdle samples of various designs (differing shape, material, pattern, etc.) manufactured by the same company and discussed the relationship between comfort and clothing pressure. The data for the clothing pressure of the most comfortable brassiere sample were obtained. It was found the clothing pressure at the lateral top areas of the cup varied depending upon the cup type, and different types of sample recorded different clothing pressures at different points.

2.3.2 Physical pressure test methods

The use of the garment pressure test method and equipment are important in the study of pressure and comfort. Some of the pressure testing methods have previously been used in the research are as explained as follows.

In the 1980's a small sensor, some 6mm in diameter and 0.6mm thick, was developed to provide accurate measurements of clothing pressure (Tsuchida, 1988). The incorporation of a wireless link enabled measurements to be recorded whilst the subject was exercising.

Fan et al (2005) used the SD500 digital skin evaluator with a 10 cm diameter sensor to test the pressure of girdles on a standard mannequin dummy and to predict the pressure on the different areas of the human body. The SD500 Skin Pressure Evaluator is portable and the pressure values, in mmHg, are displayed on a digital screen (Talley, 2006).

Another item of equipment, widely used for measuring the pressure of medical compression and support hosiery, is the Salzmann Medico's MST MK III Pressure Tester. This consists of a control unit and probes that may be placed in specific focal areas underneath the garment (Salzmann).

The Bra Meter, produced by Open Ergonomics Ltd, is a hand-held pressure gauge, specifically designed to measure the pressure under a bra. The meter uses a 14 mm

diameter thin-film plastic cell filled with incompressible silicone fluid, which is placed inside the bra. The cell is connected, via a 150mm length of tubing to a piezo-electric transducer, which in turn drives a numerical LCD display. A compensator tube of fluid, attached to the balancing port of the transducer, compensates for the weight of fluid in the connecting tube when this is not horizontal. The transducer drives a numerical LCD display, calibrated in kilopascals and to an accuracy of 0.1 kPa. Repeatability is then +/- 0.3 kPa even when inverted between readings (Open Ergonomics, 2001).

2.4 Psychological sensations of pressure and discomfort

The wearer's evaluation of the fit and comfort of clothing is closely allied to his perception of comfort and skin sensations. The use of psychophysical methods of measuring clothing comfort has opened a new era in research because the wearer's perceptions and evaluation are the final determiners of the fit of a bra.

2.4.1 Sensation and perception

Psychophysics is a scientific field that deals with measuring sensory perception. The main subfields in psychophysics are detection, identification, discrimination and scaling, and of these, scaling is most important for the field of perceived stimulation. The use of scaling is an attempt to give a numerical objective value to the subjective assessment of the sensation experienced (X). X may be a physical stimulus, a sensation or some complex psychological variables such as similarity or even pleasantness. It is desirable that a numerical value be given to the magnitude of X. A scale is a rule by which numbers are assigned to objects or events. The scale attempts to represent numerically some property of those objects or events.

The first person to attempt to describe the relation between stimulus intensity and sensation intensity was Gustav Theodor Fechner. Fechner's law reveals a logarithmic relation

between the intensity of sensation and the intensity of physical stimulus. Then, S. S. Stevens used magnitude estimation to establish his power law, which states that the relation that the magnitude of sensation varies as the intensity of the physical stimulus raised to some power. A detailed explanation of the relationship between stimulus and sensation may be found in Coren (1993).

2.4.2 Recent literature relevant to the sensations of pressure and comfort

Makabe et al (1993) measured clothing pressures in the waist area under a corset and suspender belts and carried out a sensory test on the subjects in relation to the clothing pressure, to produce a simple relationship between the pressure and the subjects' sensation.

Sasaki et al (1997) evaluated the comfort of clothing by mental impression and physical properties. The comfort of girdles was discussed by comparing sensory evaluation and dynamic clothing pressure measurement. Sensory evaluation of girdles made from different materials indicated that the girdles made of high-stretch material do not feel tight on the subject's body.

Chan (2002), using fundamental psychophysical scaling methods for the evaluation of the tightness of support garments (girdles), investigated the relationship between the subjective tightness sensation and the pressure of the girdles. It seems that this method may provide a suitable way of evaluating the comfort properties of bras.

There is not so much existing literature relating to the physical pressure caused by garments and the personal sensations of the wearer, and further, the relationships between pressure and the comfort sensation are not discussed in any depth. Some of the research pays much attention to girdles, but neglects the bras. Therefore, the research on the psychophysics of sensations caused by wearing a bra has been largely required.

2.4.3 Evaluation methods

Using fundamental psychophysical principles, a large amount of research has been carried out in different research field to investigate the relationship between a stimulus and the sensation experienced, and further psychophysical scaling have been established.

'Psychophysical scaling is a method for measuring the subjective, psychological qualities (e.g., symptoms, complaints, annoyance) of physical event (e.g., airborne dust content) based in perception psychology, physiology, and phenomenology'. In many ways, scaling remains one of the most arcane and misunderstood aspects of social research measurement. And, it attempts to do one of the most difficult of research tasks - measure abstract concepts (Trochim, 2006).

Scales are generally divided into two broad categories: unidimensional and multidimensional. The unidimensional scaling methods were developed in the first half of the twentieth century and are generally named after their inventor. The three types of unidimensional scaling methods are Thurstone or Equal-Appearing Interval Scaling, Likert or 'Summative' Scaling and Guttman or 'Cumulative' Scaling. In this research project, unidimensinal scaling is used to measure sensations.

Thurstone was one of the first and most productive scaling theorists. He actually invented three different methods for developing a unidimensional scale: (1) The method of equal-appearing intervals; (2) The method of successive intervals; and, (3) The method of paired comparisons. The three methods differed in how the scale values for items were constructed, but in all three cases, the resulting scale was rated in the same way by respondents. To illustrate Thurstone's approach, the easiest method of the three to implement, the method of equal-appearing intervals, usually uses a rating scale where:

1=least favourable to the concept

.....

11=most favourable to the concept

Likert Scaling is a type of psychometric response scale often used in questionnaires, and is the most widely used scale in survey research, usually using a 1-to-5 rating scale where:

1= strongly unfavourable to the concept

2= somewhat unfavourable to the concept

3= undecided

4= somewhat favourable to the concept

5= strongly favourable to the concept

Guttman scaling is also sometimes known as cumulative scaling or scalogram analysis. The purpose of Guttman scaling is to establish a one-dimensional continuum for a concept you wish to measure. This means, essentially, that a set of items or statements is presented so that a respondent who agrees with any specific question in the list will also agree with all previous questions. Put more formally, item responses would be able to be predicted perfectly knowing only the total score for the respondent. For example, imagine a ten-item cumulative scale, if the respondent scores a four, it should mean that he/she agreed with the first four statements, if the respondent scores an eight, it should mean they agreed with the first eight. The object is to find a set of items that perfectly matches this pattern. In practice, it is seldom that this cumulative pattern is achieved perfectly. Therefore, the scalogram analysis is used to examine how closely a set of items corresponds with this idea of cumulativeness.

Another newly developed scaling method introduced in 1998, Borg's Perceived Exertion and Pain Scales (1998), has been widely used in recent years.

There are two variations of the Borg's scales: the Borg RPE scale and the Borg CR10 scale. The Borg RPE scale, a scale for ratings of perceived exertion (RPE), was developed to enable reliable and valid estimations of perceived exertion. The Borg CR10 scale is more complicated than the Borg RPE scale in its construction. The construction of the CR10 scale makes it possible to determine growth functions for different modes, to compare them with physiological growth functions, and to make direct estimates of intensity levels for

interindividual comparisons. The CR10 scale is a general intensity scale that may be used to estimate most kinds of perceptual intensities. It is now commonly used to estimate pain intensity, and it is also frequently used in the area of human factors and ergonomics to evaluate difficulties or complaints in manual materials handling, and, also for other perceptions, such as taste or loudness. The construction of the scale is shown in Table 2.7.

Table 2.7 The Borg CR10 Scale

0	Nothing at all	'No P'
0.3		
0.5	Extremely weak	Just noticeable
1	Very weak	
1.5		
2	Weak	Light
2.5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	Extremely strong	'Max P'
11		
~		
•	Absolute maximum	Highest possible

Borg CR10 scale
©Gunnar Borg, 1981,1982,1998

Borg CR10 scale is described as a general intensity scale and can be used effectively in estimate pain intensity. Neumann (2001) has used the Borg CR10 scale to measure the socket pressure and discomfort of an artificial limb. Therefore it seems that this scale can usefully be used in this research project for measuring the pressure, discomfort and pain sensations caused by wearing a bra.

2.5 Previous research surveys relevant to women's bras

There are a lot of existing surveys relating to woman's bra. Mintel's Underwear Retailing Survey Report (2005b, 2006) is an example. It examines retailers that sell lingerie, underwear, nightwear and hosiery through various channels of distribution. However this report is only a general report on underwear, not specifically on bras.

Another report from Mintel is the Bras and Pants Survey Report (2003, 2005a); this gives a revenue-driving understanding of the UK bras and pants market, providing sufficient information to focus marketing activity towards real demand and real opportunity. It provides a major overview of the developments that have shaped the market over the last two years, examining the category and its sectors in great detail. In addition, this report also contains exclusive insight into the consumer needs that underpin and determine the market dynamics, further bolstering market knowledge. This report is a professional report on bras and pants and the sample size is quite large; but its focus area is mainly in the retail market, not in people's feelings and sensations about bra. There is insufficient data for any study of the sensations occurring when wearing a bra.

Two further articles are from Japan. The data from a study of 'Survey on the wearing conditions of underwear' (Shimizu et al., 1987) is now quite old and as it is a survey carried out amongst Japanese women, the findings may not be applicable to British women. Schlomski et al (2001)'s study 'Half of all women are wearing the wrong size of bra-it's no wonder' researched the body size of woman, and provided some useful suggestions in bra design and construction, but it still does not consider the pressure and sensations caused by wearing a bra.

There are many surveys and reports on the topic of bras to be found on the internet. However most of these are on the websites of lingerie companies, and are mainly concerned with fashion trends, styles, patterns and colour.

Chapter Three

Research methodology

3.1 Introduction

The main aims and objectives of this research are obtaining knowledge of bra fitting issues relating to the pressures and sensations experienced by the wearers of bras, and to discover information probably useful for the improvement of bra fittings.

Based on the literature review, the current problems in bra fittings aroused the research questions below:

(1) What is the pressure distribution caused by the bra to the breasts?

(2) Which kind of wearers' sensations can be trigged by wearing a bra? How to evaluate these sensations? Can psychophysical methods be used to evaluate the sensations?

(3) Do the wearers' bra wearing habits influence their sensations caused by wearing a bra?

(4) What are the relationships between the pressures and the sensations?

Two main research methodologies, survey and experiment, were employed in this research.

From the current literature, there is not enough information available about women's bra and the bra wearing habits, but this information is essentially required to carrying out the further investigation into the pressures and sensations by wearing a bra. Therefore, a survey for collecting the current data of woman's bra size, wearing habits and attitudes to bra,

women's sensations of pressure and comfort caused by wearing a bra was designed to be carried out. This information can be used to analyse the diversity and the commonness of woman's sensations caused by wearing a bra, the results may be used to design the bra pressure and sensation tests and understand the wearers' opinions towards the bra.

Tests of bra pressure and wearers' sensations caused by wearing a bra were based on psychophysical and statistical methods to investigate the relationships between the pressures and the sensations. The tests were designed by using a specific of equipment to measure the pressures in different areas of the breasts caused by the bra, using psychophysical methods to evaluate the sensations, and using statistical methods to find out the information and relationships amongst the data. The results of this analysis may be used to improve bra fitting and bra pattern design.

The survey study focused on the research questions described as below:

(1) The current bra sizes of the women.

(2) The bra wearing habits of the women.

(3) The women's attitudes towards bras.

(4) Any relationships amongst women's wearing habits, women's attitudes towards bra and women's demographic characters.

(5) The degree of any difference amongst the respondents from different ethical origins.

(6) The amount of the women's pressure, discomfort, and pain sensations caused by wearing the bra, their distributions in different areas of the bra, and any relationships with women's age or bra wearing habits.

The research questions existing in the pressure and sensation tests are described as follows:

(1) What is the pressure distribution in different areas of the breasts caused by wearing a bra?

(2) How much are wearers' sensations of pressure, discomfort and pain caused by wearing a bra?

(3) Are there any relationships between pressures and sensations?

(4) Do the data have any relationships with the data obtained from the survey?

3.2 Survey design and process

3.2.1 Survey design

The purpose of the survey is to produce statistics, that is, quantitative or numerical descriptions about some aspects of the study population. The main way of collecting information is by asking people questions; their answers constitute the data to be analysed. In this survey, generally information was collected from only a fraction of the population, that is, a sample, rather than from every member of the population (Fowler, 2002)

A sample survey brings together three different methodologies: sampling, designing questions and data collection, their combination is essential to good survey design.

3.2.1.1 Sampling

Sampling is selecting a small subset of a population representative of the whole population. The keys to good sampling are finding a way to give all or nearly all population members the same chance of being selected, and to use probability methods for choosing the sample. How well a sample represents a population depends on the sample frame, the sample size and the specific design of selection procedures. If probability sampling procedures are used, the precision of sample estimates can be calculated.

Sample frame: This survey is about woman's bra, so undoubtedly, the sample frame is the population who wear bras, that is the adult female over 16 years old in the world.

Sample selecting methods: Whereas the limitation of time and resources of this PhD study, the sample selection was mainly carried out at De Montfort University, the diversities of

female students and staff from the university can match the standard of the sample frame. There are three groups of respondents. The first group of respondents was selected by using simple random sampling from the students or staff in the library, catering areas and offices. The second group of respondents was selected by the grouped students from the class in the university; the grouped respondents are a good complementary to the simple random selected respondents. The last group of respondents were selected from China; the data from this group of respondents can be used to compare with the respondents from UK.

Sample size: According to the sample size determination method, the characteristic of this study and the restriction of time and resources, an appropriate sample size of 200-300 are adapted.

3.2.1.2 Questionnaire design

Using questions as measures is another essential part of the survey process. In survey design, answers are of interest not intrinsically but because of their relationship to something they are supposed to measure. Good questions are reliable, providing consistent measures in comparable situations, and valid, answers correspond to what they are intended to measure.

Therefore, according to the characteristics of this study, the questions and the questions distribution of the questionnaire should obey the rules as follows:

(1) This questionnaire was designed to be answered by adult females from various backgrounds, therefore the questions should be easy to understand, and the order of the questions should be easy to follow.

(2) To avoid the respondents' impatience of answering the questionnaire, the length of the questionnaire should not be too long, and the total time of answering a questionnaire should be controlled within 25 minutes

(3) In order to increase the reliability of the answers and the comparability of the data, the type of closed questions should be used where possible.
(4) Figures may be used in the questionnaire to make the questions to be easily understood.

The contents of questionnaire were carefully investigated and designed, for some of the questions, the Likert Scaling was used (A detailed explanation of Likert Scaling is shown on Section 2.4.3). The questions, as shown as follows, were divided into four parts based on the purposes of the questions. A full preliminary questionnaire was shown in the appendix A.

Header: The serial number of the questionnaire, the time and the date

Title: The title of the survey

Because the data of this survey are mainly used to analyse women's sensations of bra pressure and comfort, therefore this questionnaire is called 'Woman's Bra Pressure and Comfort Survey'.

Introduction: Brief introduction of the questionnaire was given to the respondents, this included the aim of this questionnaire, the researcher of this survey, the contents and the approximate time required to answer the questionnaire.

Part one: Demographic questions of the age, the weight, the height and the ethnic origin

Part two: Questions about women's bra wearing habits

Wearing bra or not, how often and how long of wearing a bra?

The age of beginning to wear a bra

Bra size

Numbers of bras owned, new bras and the duration of a bra

Wearing habits relating to the sports bra

The medical problems of women's breasts

Part three: Questions about women's attitudes towards bras

Agree or disagree with some statements relating to bras

Opinion about the relationship between wearing a bra and the breast health problems

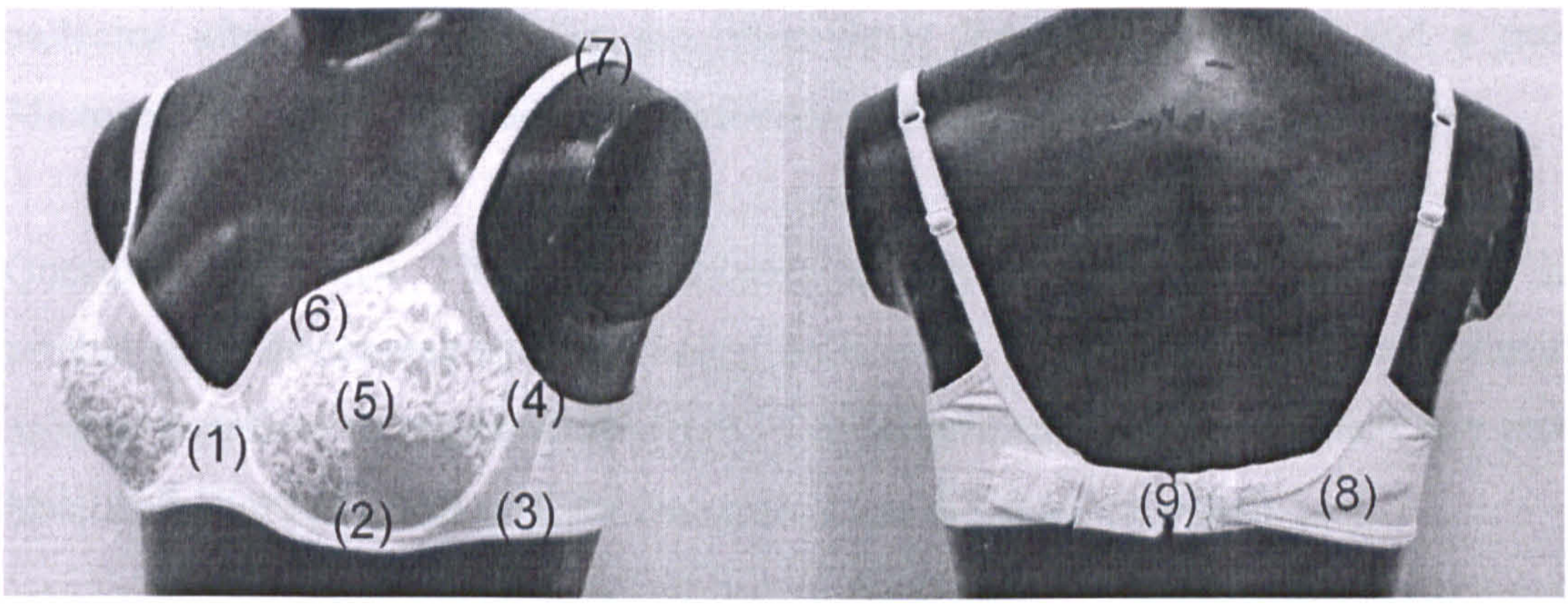
The preferred styles of the bra

The preferred support of the bra

The sequence of importance of the bra properties

Satisfaction about bras

The fit distributed in different areas of the bra. As shown in Figure 3.1, the respondents were asked to give their opinions of fitness in nine different areas distributed in the bra.



1: Centre front 2: Centre underband 3: Lower underarm 4: Upper underarm 5: High point of bust 6: Centre neck edge 7: Strap 8: Wing back 9: Centre back

Figure 3.1 Focal areas

Part Four: Questions about women's sensations of pressure, discomfort and pain by wearing a bra.

The sensations of the amount of pressure in different areas of the bra (use Fig. 3.1)

The sensations of the amount of discomfort in different areas of the bra (use Fig. 3.1)

The sensations of the amount of pain in different areas of the bra (use Fig. 3.1)

Finally, acknowledgement and thanks were given to the respondents.

3.2.1.3 The survey process and its management

The choice of data collection mode, mail, Internet, telephone, personal interview, or group administration, is related directly to the sample frame, research topic, characteristics of the sample, and available staff and facilities; it has implications for response rates, question form, and survey costs. Computers can be used in the data collection process via all of these modes.

Mode of data collection: The data collection method of this survey is self-administrated. For the respondents in UK, the printed questionnaires were distributed individually, and collected after completion. For the respondents from China, e-mail and a protected Microsoft Word file were used for distribution and collection of the questionnaire.

Questionnaire format: There are two types of questionnaire format used in this survey: printed paper documents and electronical documents. The printed paper questionnaire was used to distribute to respondents in UK. The electrinical document, which is a protected Microsoft Word file, was used for the respondents in China via e-mail.

Questionnaire language version: The language of the questionnaire for respondents in UK is English, and the language of the questionnaire for Chinese respondents is Chinese. The Chinese version is a strictly translated document from English version; all the contents of the questions, the total numbers of the questions, and the sequence of the questions from the two versions are exactly the same.

The process and the time management of the whole survey are described as follows:

Survey plan: 1-2 weeks

Sample and questionnaire design: 3-5 weeks

Pilot survey and revision: 1-2 weeks

Survey: 4-6 weeks

Data analysis: 4-6 weeks

Report writing: 2-4 weeks

Total time: 15-25 weeks

The whole process of the survey is illustrated by flow chart as Figure 3.2.

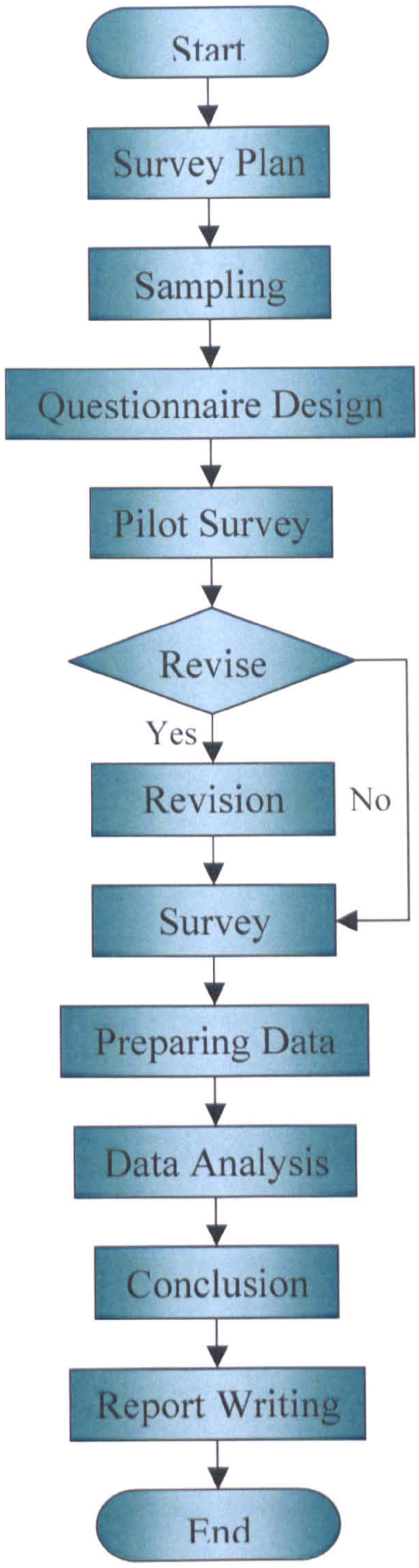


Figure 3.2 The flow chart of the survey process

3.2.2 The pilot survey and questionnaire revision

Designing a good survey instrument involves selecting the questions needed to meet the research objectives, testing them to make sure they can be asked and answered as planned, then putting them into a form to maximize the ease with which respondents and interviewers can do their jobs. A good way to test the survey is pilot testing, or pretesting the survey instrument with a small sample population, this is one of the most important stages in the development of a new survey instrument. Pilot testing has three main benefits: it helps to identify errors in the survey, allows learning where the survey instrument may need redesign, and predicts possible problems may encounter in using the instrument (Litwin, 2002).

The aim of the pilot survey is to investigate if the questionnaire is able to gather the data needed for the study and if it is easy and clear for respondents to answer. Then, based on the feedback of the pilot survey, the questionnaire and the survey process will be revised to avoid mistakes or problems which might occur in the real survey.

3.2.2.1 The pilot survey process

Ten respondents from the sample frame were selected to attend the pilot survey. Every respondent was interviewed individually. Firstly, the questionnaire was shown to the respondent with instructions of how to answer the questionnaire. Secondly, the starting time, duration, and the finishing time for answering the questionnaire were recorded. Any problems the respondents might meet during answering the questionnaire were recorded. Thirdly, in the end, a feedback questionnaire was shown to the respondent, a conversation was carried out between the surveyor and the respondent, the opinion of the respondent to the questionnaire and the problems occurred during answering were recorded. The flow chart of the whole process is illustrated as Figure 3.3.

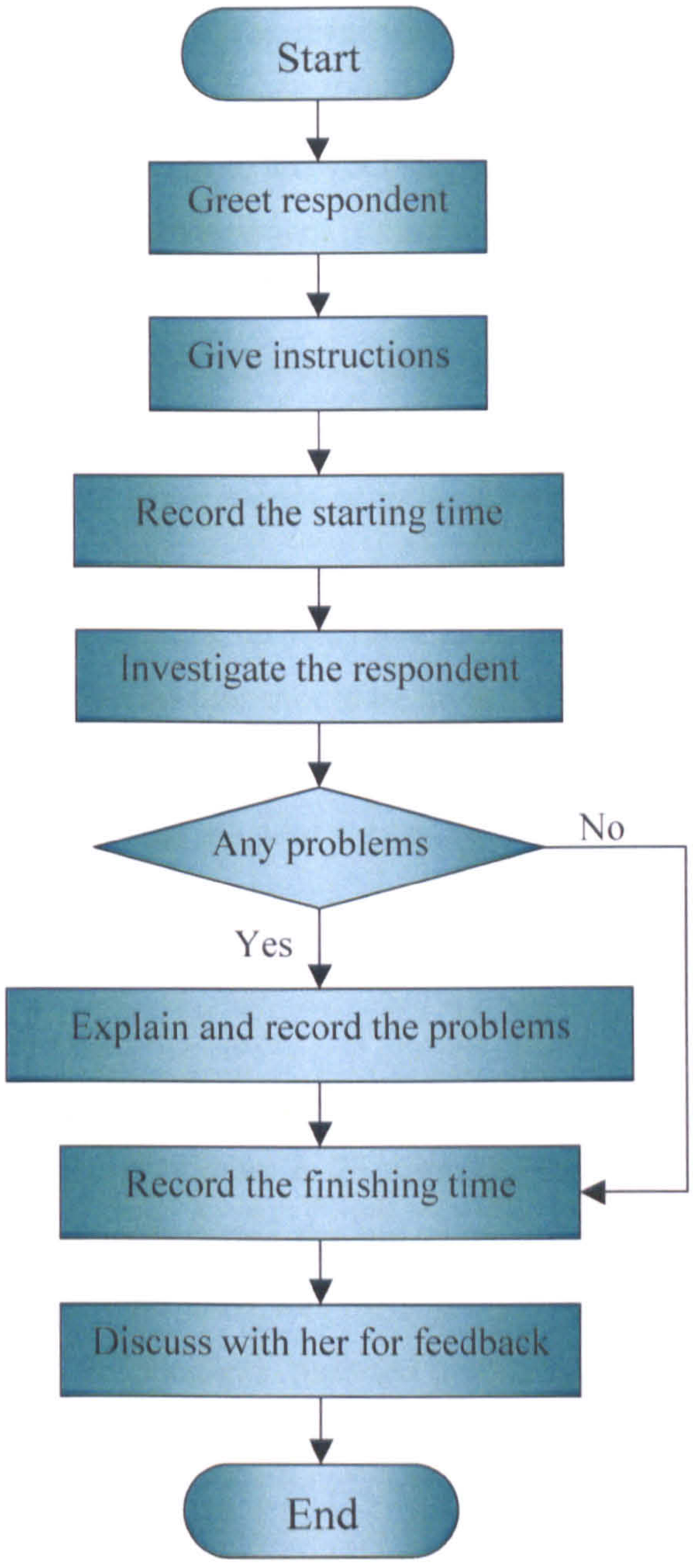


Figure 3.3 Flow chart of pilot survey process

3.2.2.2 The feedback questionnaire

In order to obtain the respondents' comments for the questionnaire and make an improvement to the questionnaire, the respondents were asked some questions relation to the questionnaire, they are described as follows:

(1) Do you think the time you used to answer the questionnaire is reasonable?

(2) Do you think the question arrangement is easy to follow?

(3) Do you think the length of the questionnaire is appropriate?

(4) Do you think the length of the individual questions is appropriate?

(5) Do you think the questions are as specific as possible?

(6) Do you think there are some words or expressions in the questions that are hard to understand?

(7) In the multi-selection questions, do you think all of the reasonable selections are listed?

(8) Are there any other problems that should be improved?

3.2.2.3 Results and discussion of the pilot survey

1. Duration of the questionnaire

From analysing the duration for answering a full questionnaire, it is found that the minimum is 5 minutes, the maximum is 23 minutes, and the average time is 14 minutes. Only two of the respondents reported the questionnaire is a bit long. For native English speaking respondents, the time used was far more less than non-native English speaking respondents. All of the respondents reported the length of the questionnaire and the questions is appropriate, and the question arrangement is easy to follow.

2. The answering process

Most of the respondents have answered the questionnaire fluently, no inquiry during the answering, and finished with no missed and misunderstood answers. Two respondents encountered misunderstanding of the words or questions, therefore the expression of the questions should be further refined, or the respondents should be encouraged to inquiry

from the surveyor during answering the questionnaire. Three respondents encountered the situation of missing answers because there are two questions below one title, so this question should be divided into two questions to avoid this problem.

3. Other feedback

(1) Two of the respondents reported that there should be the factors influencing the discomfort sensations, therefore a question about it should be considered to add into the questionnaire.
(2) There is one respondent who finished answering at an early stage of the questionnaire, this situation is not considered unusual, and therefore such cases should be considered in the real survey.

4. Revision of the questionnaire

(1) Correct the mistakes in spelling and grammar, improve the expressions of sentences to avoid misunderstanding.
(2) Split some longer questions into two or three questions.
(3) Add some new questions which are useful to this study.
(4) Change the format of the key words in the questions into capital words; it is then easy to focus on the meaning of the questions to the respondents.

From the pilot survey, there is only minor revision required for the questionnaire. It is confirmed that the methodology and the design of the survey are appropriate. Revised final edition of the questionnaire in English and Chinese visions are shown in Appendix B and C.

3.2.3 Survey Process

The real survey was carried out in two processes, the individual interview and the e-mail survey, which are shown in Figure 3.4 and Figure 3.5. A record form of the survey which is

used to record the time, place, and the description of the survey process is shown in appendix D.

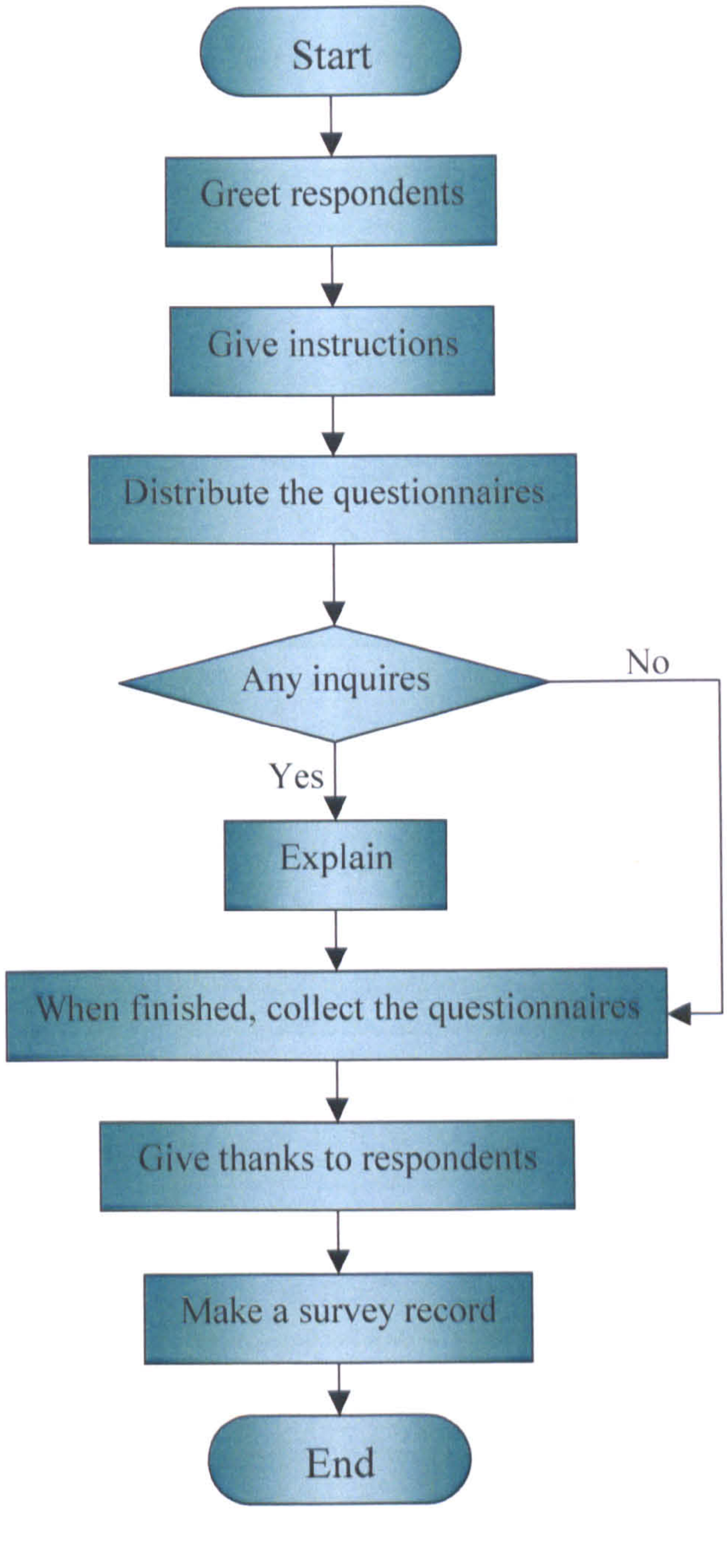


Figure 3.4 The flow chart of individual interview

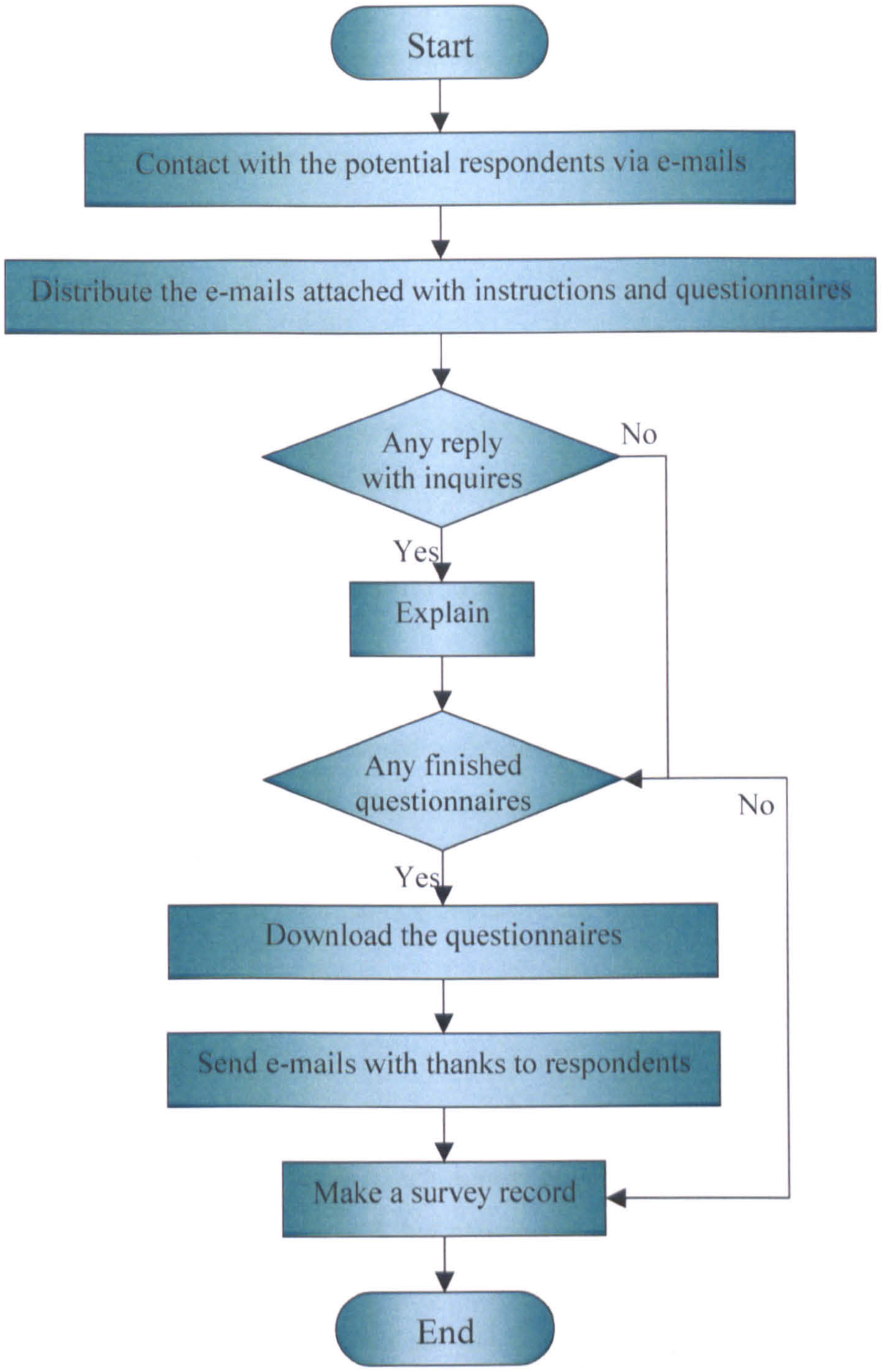


Figure 3.5 The flow chart of E-mail survey

3.2.4 Data analysis process

Once data have been collected by a survey, no matter what the method, they almost invariably must be translated into a form appropriate for analysis by computer. The process of preparing survey data for analysis include data formats, code development, coding procedures and management, data entry and data checking procedures.

3.2.4.1 Data formatting and coding

The statistical software used to analyse the data is SPSS for Windows 11.5. SPSS provides a powerful statistical analysis and data management system in a graphical environment, using descriptive menus and simple dialog boxes to do most of the work. Therefore, the data from the survey were formatted and coded in accordance with the rules of SPSS.

The serial number of the respondents: Each respondent was given a serial number which is expressed by a 6 digital code combined with alphabet and number. The first two digits is GR (grouped respondents) or IN (Individual respondents), the third digit represent the number of group or individual, the last three digits represent the number of respondents. For example, GR3011 mean the 11th respondent in Group 3.

The questionnaire type: Based on the extent of missing answers, the questionnaires were divided into 6 types:

A: No missing answers for all the questions.

B: Missing answers in Part 1, no missing answers in Part 2, 3 or 4.

C+: Missing answers in Part 2, 3, or 4, but no missing answers in Q.22, 23, 24, and 26.

C-: Missing answers in Q.22, 23, 24, or 26.

D: Not finished questionnaire, which are the questionnaires with missing answers more than 70% of the whole questionnaire

E: The answering is stopped at the Q.5.

The data of different types of questionnaires will be used in data analysis for different purpose.

The missing data rule: There are two kinds of missing data. One is from the questions which don't need to be answered, that means the respondents don't need to answer this question due to the instruction of the answering process, this kind of missing data is coded as a missing value of 888. The other is from the questions which the respondents need to answer, but missed to answer, this kind of missing data is coded as a missing value of 999.

3.2.4.2 Data cleaning

In addition to the coding of the missing data as explained above, further explanation for dealing with the missing data will be given in Chapter 4 and Chapter 5. Due to the requirement for analysis, there are some data which need to be recoded; it will be explained in Chapter 4 and Chapter 5.

3.2.4.3 Statistical methods used in the data analysis

The main statistical methods used in the analysis of the survey data were explained as follows (SPSS, 2002).

Frequencies: Frequency or one-way tables represent the simplest method for analyzing categorical (nominal) data. They are often used as one of the exploratory procedures to review how different categories of values are distributed in the sample. Summaries of individual variables provide an important 'first look' at data. Some of the tasks that these summaries help to complete are listed below.

(1) Determining 'typical' values of the variables.

(2) Checking the assumptions for statistical procedures.

(3) Checking the quality of the data.

The Frequencies procedure is useful for obtaining summaries of individual variables.

Means: The Means procedure is useful for both description and analysis of scale variables. Using its descriptive features, it can be requested a variety of statistics to characterize the central tendency and dispersion of the test variables. Any number of grouping variables can be layered, or stratified into cells that precisely define the comparison groups. Using its hypothesis testing features, the differences can be tested between group means using one-way ANOVA. The one-way ANOVA in Means provides linearity tests and association measures to help understand the structure and strength of the relationship between the groups and their means.

Crosstabulation tables: Crosstabulation tables (contingency tables) display the relationship between two or more categorical (nominal or ordinal) variables. The size of the table is determined by the number of distinct values for each variable, with each cell in the table representing a unique combination of values. Numerous statistical tests are available to determine whether there is a relationship between the variables in a table.

Chi-Square Test: The Chi-Square Test procedure tabulates a variable into categories and computes a chi-square statistic. This goodness-of-fit test compares the observed and expected frequencies in each category to test either that all categories contain the same proportion of values or that each category contains a user-specified proportion of values.

Correlation analysis: Correlation is a measure of the relation between two or more variables. The measurement scales used should be at least interval scales, but other correlation coefficients are available to handle other types of data. Correlation coefficients can range from -1.00 to +1.00. The value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation. A value of 0.00 represents a lack of correlation. The most widely used type of correlation coefficient is Pearson r, also called linear or product- moment correlation.

Skewness: A measure of the asymmetry of a distribution. The normal distribution is symmetric, and has a skewness value of zero. A distribution with a significant positive skewness has a long right tail. A distribution with a significant negative skewness has a long left tail. As a rough guide, a skewness value more than twice its standard error is taken to indicate a departure from symmetry.

K-means cluster analysis: K-means cluster analysis is a tool designed to assign cases to a fixed number of groups whose characteristics are not yet known but are based on a set of specified variables. It is most useful when classifying a large number of cases. The K-Means Cluster Analysis procedure begins with the construction of initial cluster centres. It can be assigned by the analyzer itself or have the procedure select k well-spaced observations for the cluster centres. After obtaining initial cluster centres, assigns cases to clusters based on distance from the cluster centres, then, updates the locations of cluster centres based on the mean values of cases in each cluster. These steps are repeated until any reassignment of cases would make the clusters more internally variable or externally similar.

3.2.5 Ethical Issues arising in the survey

Another important issue in survey is ethical issues. As in all research that involves human subjects, the survey researcher needs to be attentive to the ethical manner in which the research is carried out. A basic guideline is that the researcher should make sure that no individual suffers any adverse consequences as a result of the survey. Moreover, to the extent that it is feasible, a good researcher also will be attentive to maximizing positive outcomes of the research process.

In the beginning of this PhD study, the approval for this study was obtained from the Human Research Ethics Committee of De Montfort University; therefore the survey was carried out and protected under the regulation of this committee.

In order to protect the respondents, some guidance, which were listed below, were obeyed during the whole session of the survey:

(1) Before the survey, the respondents should be given the information that this is a PhD research project, and the information of the surveyor's name, department, and faculty.

(2) A brief introduction of the survey, the purposes of this research should be given to the respondents.

(3) The respondents should be given the information that the data obtained from the survey are protected with respect to confidentiality.

(4) Assurance that cooperation is voluntary and that no negative consequences will result to those who decide not to participate in the survey study.

(5) Assurance that respondents can skip any questions that they do not want to answer.

(6) Minimize links between answers and identifiers. In this study, the respondents don't need to provide their names and addresses.

(7) Completed survey returns will not be accessible to non-project members. The author of this research is the only person who can access the original questionnaires from the survey.

3.3 The design of the pressure and sensation tests

This section is mainly discussed about the design of the pressure and sensation tests, psychophysical and statistical analysis were used to investigate the relationships between the pressure and sensations caused by wearing a bra.

3.3.1 Human subjects and sample bras

3.3.1.1 Human subjects

Based on the availability and resources of this study, the female university students were selected as the test subjects, the numbers of subjects was within 20-30.

3.3.1.2 Selection of the sample bras

To the selection of sample bras, two factors were paid more attention to. First is the pattern of the bras. This research is focused on the comparison of the data from different subjects; therefore, in order to avoid the different distribution of pressures caused by wearing a bra with different patterns, only one pattern of the bra was selected in this study. Based on the popularity of bra pattern, the basic underwired unpadded pattern was selected.

The other factor is the size of the sample bras, because the breast sizes of the subjects are various, a large range of sizes of the sample bras was required. Due to the limitation of the resources, it is difficult to obtain the bras with the same pattern in almost all of the sizes, but this problem can be solved by using the sample bras of a little range of sizes, and then transferring them into more sizes. Based on the bra sizing system, some of the different sized bras have the same patterns in bra cup and cradle, only have difference in bra wing; therefore, modifications can be made in the bra wing to suit different sized women. The bra sizes selected and the other sizes which can be transferred into are shown in Table 3.1.

Table 3.1 Bra sample size

Bra sample size	Can be transferred into other sizes
34B	30D 32C 36A 38AA
34C	30DD 32D 36B 38A 40AA
34D	30E 32DD 36C 38B 40A 42AA
34DD	30F 32E 36D 38C 40B 42A 44AA
34E	30G 32F 36DD 38D 40C 42B 44A 46AA
34F	32G 36E 38DD 40D 42C 44B 46A 48AA

Based on what described above, Berdita underwired bras supplied by Macrimex (UK) Limited were selected as the sample bras, the images of the sample bras are shown in Figure 3.6.

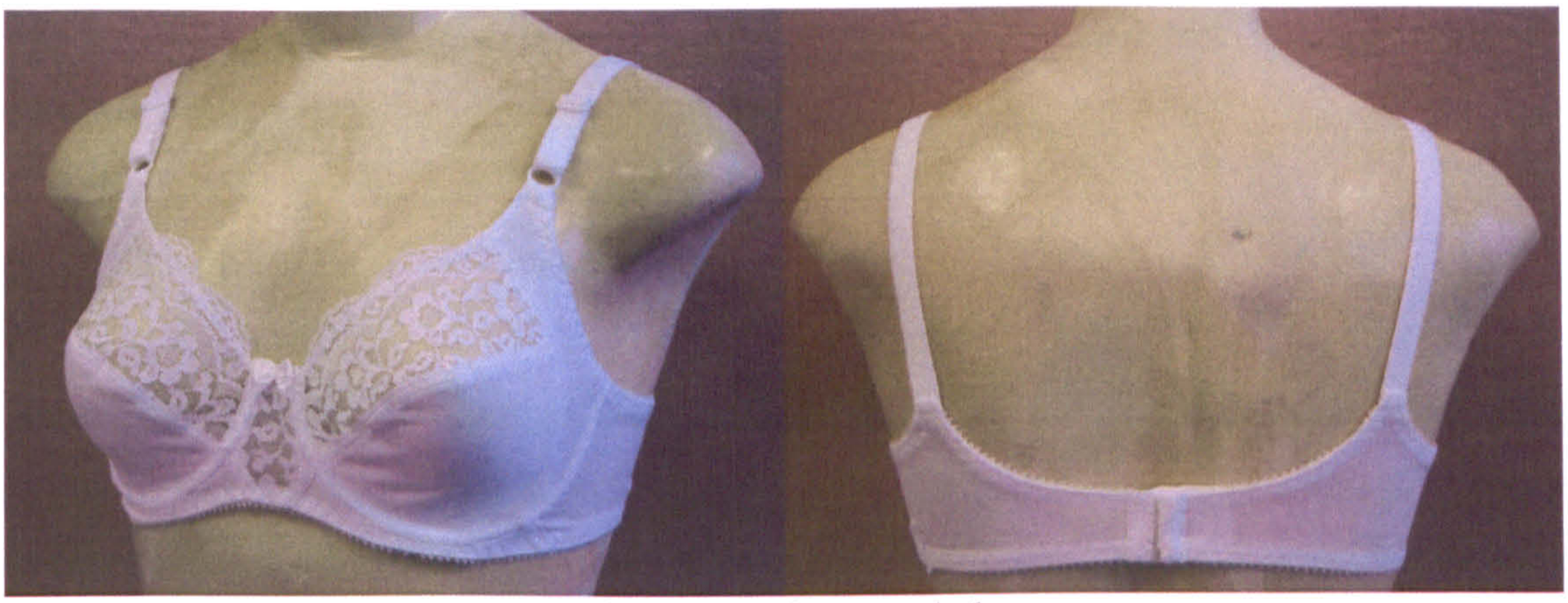
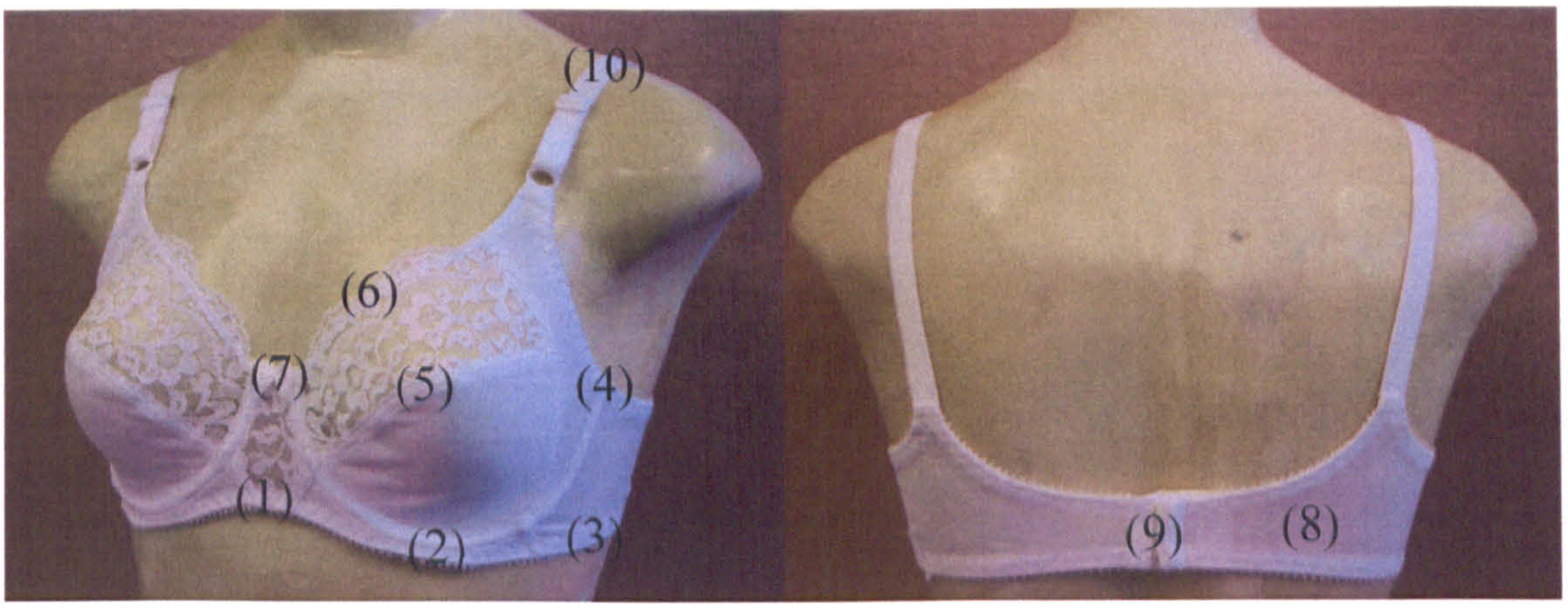


Figure 3.6 The sample bra

3.3.1.3 Focal areas

The ten focal areas which are important to bra fitting are shown in Figure 3.7.



1: Lower centre front 2: Centre underband 3: Lower underarm
4: Upper underarm 5: High point of bust 6: Centre neck edge
7: Upper centre front 8: Wing back 9: Centre back 10: Strap
Figure 3.7 Focal areas

The focal areas on the sample bras of the tests are almost the same with the focal areas in the survey (see Figure 3.1), but slight modifications of the focal areas on the sample bras used in the tests have been made. The centre front of the bra was divided into two areas of

upper centre front and lower centre front, because this part in the sample bras is quite wide and the pressure in the upper part and the lower part is quite different. Besides, there were no other changes.

3.3.1.4 Modification of the sample bras

As discussed above, the sample bras are required to be transferred to other sizes, so the length of the bra wing needs to be changeable for different levels of pressure distributions to be obtained when wearing. Therefore, slight modifications have been made to the sample bras that the length of the back wings in the bra can be adjusted during the tests. The sample bras were modified by sewing more fastenings on the bra wings, and then the length of the bra wings can be adjusted. The original whole underbust girth and the modified whole underbust girth of the sample bras are shown in Table 3.2.

Table 3.2 Whole underbust girths of the sample bras

Unit: cm

	1	2	3	4	5	6	7	8	9	10	Original girth
34B	78.0	75.9	73.8	71.7	69.6	67.5	65.4	63.3	61.2	59.1	68.0
34C	79.6	77.5	75.4	73.3	71.2	69.1	67.0	64.9	62.8	60.7	68.2
34D	79.5	77.4	75.3	73.2	71.1	69.0	66.9	64.8	62.7	60.6	68.5
34DD	78.2	76.1	74.0	71.9	69.8	67.7	65.6	63.5	61.4	59.3	68.2
34E	81.2	79.1	77.0	74.9	72.8	70.7	68.6	66.5	64.4	62.3	67.8
34F	80.6	78.5	76.4	74.3	72.2	70.1	68.0	65.9	63.8	61.7	67.8

The straps of the sample bras are also one of the focal areas; therefore the strap lengths of the sample bras were also measured and adjusted to obtain a different pressure distribution in this area, which is shown in Table 3.3.

Table 3.3 Strap lengths of the sample bras

Unit: cm

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
34B	30.3	29.3	28.3	27.3	26.3	25.3	24.3	23.3	22.3	21.3	20.3	19.3	18.3	17.3
34C	29.4	28.4	27.4	26.4	25.4	24.4	23.4	22.4	21.4	20.4	19.4	18.4	17.4	16.4
34D	29.1	28.1	27.1	26.1	25.1	24.1	23.1	22.1	21.1	.20.1	19.1	18.1	17.1	16.1
34DD	29.0	28.0	27.0	26.0	25.0	24.0	23.0	22.0	21.0	20.0	19.0	18.0	17.0	16.0
34E	29.0	28.0	27.0	26.0	25.0	24.0	23.0	22.0	21.0	20.0	19.0	18.0	17.0	16.0
34F	29.6	28.6	27.6	26.6	25.6	24.6	23.6	22.6	21.6	20.0	19.6	18.6	17.6	16.6

3.3.2 Pressure measurements

3.3.2.1 The equipment of pressure measurements

The pressure tester used in this research should be precise and easy to use on the surface of soft tissues of the breasts, and no harm or allergy to the skin of the breasts. A specially designed bra pressure tester, the Bra Meter produced by Open Ergonomics Ltd, was selected as the equipment of pressure measurement in this study. This is a hand-held pressure gauge developed for measuring pressure under bras. The detailed description of this equipment is shown in Section 2.3.2. A picture of the Bra Meter is shown in Figure 3.8.

The reasons for choosing The Bra Meter as the measurement equipment for this study and the characteristics of this equipment are described below:

(1) It is specially designed for the bra.
(2) It is extremely sensitive for detecting small variations in pressure, even in low-pressure interfaces like bra cups.
(3) The small low-profile sensor cell makes the smallest possible impact on the interface it is measuring.
(4) It has already widely applied in Marks and Spencer (2006) stores to test the pressure cause by wearing a bra. Since its launch in 2001, it has been used to fit over 365,000 women.

Figure 3.8 Bra Meter

Therefore, the characteristics of the Bra Meter guaranteed this equipment is suitable for the pressure measurements in this research.

3.3.2.2 The process of pressure measurements

The pressure measurements were carried out in a private area with a suitable laboratory condition at temperature of 27°C and relative humidity of 65%. The sensor of the Bra Metre was put between the skin of the breasts and the bra to test the pressure. The subjects

were asked to wear the sample bra with a standard erect standing posture and breathe normally during the whole measurements. The detailed process is described below:

(1) Ask subject to wear the sample bra.

(2) Fasten the hook of the bra into the eye with the loosest underbust girth.

(3) According to the sketch map of the focal areas in the sample bra, put the sensor specifically on the area 1, read the data of pressure and record. Repeat the same approach for area 2, until area 9.

(4) Move the hook of the bra into the next eye, repeat approach 3, until the last eye with a tightest underbust girth.

(5) Measure pressures in the strap area (Area 10). Adjust the strap lengths from the loosest to the tightest, measure the pressures and record.

3.3.3 Sensation evaluation

3.3.3.1 The psychophysical meaning of the sensations

The sensations tested for the sensation evaluation are pressure sensation, discomfort sensation and pain sensation.

The pressure sensation to a human being means a physical sensation produced by compression of a part of the body, in another word, it is the somatic sensation that results from applying force to an area of skin. In this study, the pressure sensation means a physical sensation produced by applying force to the specific areas of women's breasts by wearing a bra.

The discomfort sensation means a sensation of mental or bodily distress; it can be produced by pressure, temperature, pain, or any other factors. In this study, the discomfort sensation means a sensation of bodily distress in the specific areas of women's breasts caused by wearing a bra.

The pain sensation means an unpleasant sensation occurring in varying degrees of severity as a consequence of injury, disease, or emotional disorder. In this study, the pain sensation means a heavy somatic sensation or a strongly unpleasant bodily sensation in the specific areas of women's breasts caused by wearing a bra.

3.3.3.2 The sensation evaluation method: Borg CR10 Scale

Borg's CR10 scale was used as a subjective evaluation method for the evaluation of sensations. The construction of the scale is shown in Table 3.4.

Table 3.4 The Borg CR10 Scale

0	Nothing at all	'No P'
0.3		
0.5	Extremely weak	Just noticeable
1	Very weak	
1.5		
2	Weak	Light
2.5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	Extremely strong	'Max P'
11		
~		
•	Absolute maximum	Highest possible

Borg CR10 scale
©Gunnar Borg, 1981,1982,1998

There are three questions for the evaluation process, they are:

(1) Please use Borg CR10 Scale to select the number that best describes the amount of PRESSURE or TIGHTNESS you feel at this area in the bra.

(2) Please use Borg CR10 Scale to select the number that best describes the amount of DISCOMFORT you feel at this area in the bra.

(3) Are you experiencing any PAIN at this area in the bra?

NO

YES (If YES, please use Borg CR10 Scale to select the number that best describes the amount of PAIN you feel at this area in the bra)

Since the Borg CR10 scale is a general intensity scale constructed according to special category-ratio principles, the instructions should, however, be more detailed, simple examples were given to check that the subject has understood the scale and how to use it. When instructing the subjects, the tester must first explain the scale, show its functions, and describe how it is used, and then give specific instruction for modality or attribute to be tested. A detailed instruction is described in Table 3.5, and examples of how to use this scale are shown in Table 3.6.

Before every sensation evaluation, the subjects were given the instruction and the examples to let them understand the scale and use it correctly.

Table 3.5 General Instructions for Using the Borg CR10 Scale

General Instructions for Using the Borg CR10 Scale

You will use this scale to tell how strong your perception of a certain attribute is. As you can see, the scale stretches from 'nothing at all' to 'absolute maximum' 'Extremely strong-max P' (10) is such an extremely strong perception of a certain attribute that it is the strongest one you have ever experienced: 'max P'. It may, however, be possible to experience or to imagine a magnitude that is even stronger than what you yourself have previously experienced. Therefore, 'absolute maximum', the 'highest possible' level, is placed somewhat farther down the scale without a fixed number and marked with a '•'. If you should perceive an intensity to be stronger than 10, 'extremely strong-max P', you may use numbers on the scale above 10, such as 11, 12, or even higher. 'Extremely weak', corresponding to 0.5 on the scale, is something just noticeable, i.e., something that is on the boundary or what is possible to perceive.

You use the scale in the following way: Always start by looking at the verbal expressions. Then choose a number. If your perception corresponds to 'very weak', you say 1. If it is 'moderate', you say 3, and so on. You may use whatever numbers you want, also half values, such as 1.5 or 2.5, or decimals, e.g., 0.3, 0.8, 1.7, 2.3, 5.6, or 11.5. It is very important that you answer what you perceive and not what you believe you ought to answer. Be as honest as possible and try not to overestimate or understanding the intensities. Remember to start by looking at the verbal expressions before every rating, and then give a number.

0	Nothing at all	'No P'
0.3		
0.5	Extremely weak	Just noticeable
1	Very weak	
1.5		
2	Weak	Light
2.5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	Extremely strong	'Max P'
11		
~		
•	Absolute maximum	Highest possible

Borg CR10 scale
©Gunnar Borg, 1981,1982,1998

Any questions?

Table 3.6 Some examples of how to use Borg CR10 Scale

Some examples of items to rate. The test leader may want to use some simple items for training and testing the subject's rating behaviour, and ask the following questions: To see that you have understand the instruction and how to use the scale, please answer the following questions: 1. How black do you perceive a piece of pure black charcoal to be? (9) How white? (0.5) 2. How loud do you perceive an ordinary conversation between two people to be? (2.5) 3. How white do you perceive a piece of pure white sugar to be? (9) How black? (0.5) 4. How sour do you perceive a lemon to be? (7) 5. How sweet is a ripe banana? (3.5) The answers to these questions are given in approximate numbers. Any further questions?

3.3.3.3 The process of sensation evaluation

For the sensation evaluation tests, the subjects were asked to report the sensations of pressure, discomfort and pain by wearing the sample bra, a detailed process is described below:

(1) Ask subject to wear the sample bra.

(2) Evaluate pressure sensations. Fasten the hook of bra into the eye with a loosest underbust girth. According to Borg CR10 Scale, ask subject to select a number that best describes the amount of pressure or tightness she feel in the bra from Area 1 to Area 9, record the number. Repeat the same approach for the next eye, until the last eye with the tightest underbust girth.

(3) Evaluate discomfort sensations. Fasten the hook of bra into the eye with a loosest underbust girth. According to Borg CR10 Scale, ask subject to select a number that best describes the amount of discomfort she feel in the bra from Area 1 to Area 9, record the number. Repeat the same approach to the next eye, until the last eye with the tightest underbust girth.

(4) Evaluate pain sensations. Fasten the hook of bra into the eye with a loosest underbust girth. According to Borg CR10 Scale, ask subject to select a number that best describes the amount of pain she feel in the bra from Area 1 to Area 9, record the number. Repeat the same approach to the next eye, until the last eye with the tightest underbust girth.

(5) Evaluate the sensations in the strap area (Area 10). Adjust the strap lengths from the loosest to the tightest, evaluate the sensations of pressure, discomfort and pain according to Borg CR10 Scale.

3.3.4 A Pilot test

In order to make sure the equipment and the evaluation methods are appropriate for this study, a pilot test was carried out to check the accuracy of the measured pressures and sensations and the consistency and repeatability of the data.

3.3.4.1 The design of the pilot test

The subject of the pilot test is a randomly selected female from the potential subjects' crowd. The size of the subject and the sample bra used are shown in Table 3.7.

Table 3.7 The size of the subject

Underbust	Overbust	Calculated bra size	Sample bra size
84 cm	94 cm	38A	34C

In the standard test condition, the subject was asked to wear the sample bra, and by using an unchanged whole underbust girth, the pressures and the evaluation of sensations are measured for three times, then, the data was used to analyse the consistency and repeatability.

3.3.4.2 Discussion of the pilot test results

A nonparametric test method for multiple related samples, the Friedman procedure tests, is used to check the repeatability of the data. The Friedman test is the nonparametric equivalent of a one-sample repeated measures design or a two-way analysis of variance

with one observation per cell. A detailed explanation of Friedman test can be found in the help file of SPSS (2002).

1. The repeatability of pressure measurements

The data from pressure measurements are shown in Table 3.8.

Table 3.8 The pressure measurement results

Unit: kPa

Test \ Area	1	2	3	4	5	6	7	8	9	10
1	1.8	2.8	5.5	1.8	1.4	0.3	1.7	0.7	1.2	5.3
2	2.0	2.1	5.7	2.0	1.5	0.3	1.0	0.9	1.1	4.2
3	1.7	3.0	5.4	1.8	1.3	0.2	1.5	0.8	1.0	5.0

The results of Friedman procedure tests are shown in Table 3.9.

Table 3.9 Friedman test results

Ranks	
	Mean Rank
Pressure 1	2.20
Pressure 2	2.25
Pressure 3	1.55
Test Statistics	
N	10
Chi-Square	3.211
df	2
Significance	0.201

From the data in Table 3.8, statistical analysis from Friedman test showed that Chi-Square is 3.211, df is 2, and the Significance=0.201>0.005 (Significance at level 0.005), this indicated that there is not statistical difference amongst the data of 3 repeat tests, therefore it is proved that the pressure measurement is repeatable.

2. The repeatability of sensation evaluations

The data of pressure sensation evaluations are shown in Table 3.10.

Table 3.10 The pressure sensation measurement result

Area / Test	1	2	3	4	5	6	7	8	9	10
1	4.0	8.0	5.0	2.5	1.5	0.5	0.3	0.0	3.0	7.0
2	3.0	6.0	5.0	4.0	2.0	0.5	0.5	0.5	3.0	7.0
3	4.0	7.0	6.0	5.0	1.0	0.5	0.5	0.5	2.0	8.0

The results of Friedman procedure tests are shown in Table 3.11.

Table 3.11 Friedman test results

Ranks	
	Mean Rank
Pressure sensation 1	1.80
Pressure sensation 2	1.95
Pressure sensation 3	2.25
Test Statistics	
N	10
Chi-Square	1.400
df	2
Significance	0.497

From the data in Table 3.10, statistical analysis from Friedman test showed that Chi-Square is 1.400, df is 2, and the Significance=0.497>0.005, this indicated that there is not statistical difference amongst the data of 3 repeat tests, therefore it is proved that the pressure sensation evaluation is repeatable.

The data of discomfort sensation evaluations are shown in Table 3.12.

Table 3.12 The discomfort sensation measurement result

Test \ Area	1	2	3	4	5	6	7	8	9	10
1	0.5	0.5	5.0	5.0	1.0	0.0	0.0	1.0	0.0	3.0
2	1.5	0.5	4.0	4.0	0.0	0.0	0.0	0.0	0.0	3.0
3	1.0	0.5	3.0	3.0	0.0	0.0	0.0	0.0	1.0	2.0

The results of Friedman procedure tests are shown in Table 3.13.

Table 3.13 Friedman test results

Ranks	
	Mean Rank
Discomfort sensation 1	2.30
Discomfort sensation 2	2.00
Discomfort sensation 3	1.70
Test Statistics	
N	10
Chi-Square	3.000
df	2
Significance	0.223

From the data in Table 3.12, statistical analysis from Friedman test showed that Chi-Square is 3.000, df is 2, and the Significance=0.223>0.005, this indicated that there is not statistical difference amongst the data of 3 repeat tests, therefore it is proved that the discomfort sensation evaluation is repeatable.

The data of pain sensation evaluations are shown in Table 3.14.

Table 3.14 The pain sensation measurement result

Test \ Area	1	2	3	4	5	6	7	8	9	10
1	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	1.0
2	0.0	0.0	3.0	2.5	0.0	0.0	0.0	0.0	0.0	2.0
3	0.0	0.5	3.0	3.0	0.0	0.0	0.0	0.0	0.0	1.0

The results of Friedman procedure tests are shown in Table 3.15.

Table 3.15 Friedman test results

Ranks	
	Mean Rank
Pain sensation 1	1.95
Pain sensation 2	1.95
Pain sensation 3	2.10
Test Statistics	
N	10
Chi-Square	0.667
df	2
Significance	0.717

From the data in Table 3.14, statistical analysis from Friedman test showed that Chi-Square is 0.667, df is 2, and the Significance=0.717>0.005, this indicated that there is not statistical difference amongst the data of 3 repeat tests, therefore it is proved that the pain sensation evaluation is repeatable.

3.3.5 Data analysis and statistical methods

The statistical software used to analyse the data from the pressure and sensation measurements are Excel 2002 and SPSS for Windows 11.5.

The main statistical method used in this section is the Linear regression analysis. Linear regression is used to model the value of a dependent scale variable based on its linear relationship to one or more predictors. The linear regression model assumes that there is a linear, or 'straight line', relationship between the dependent variable and each predictor. The model is linear because increasing the value of the predictor by 1 unit increases the value of the dependent by a stable unit.

For the purpose of testing hypotheses about the values of model parameters, the linear regression model also assumes the following:

(1) The error term has a normal distribution with a mean of 0.

(2) The variance of the error term is constant across cases and independent of the variables in the model. An error term with non-constant variance is said to be heteroscedastic.

(3) The value of the error term for a given case is independent of the values of the variables in the model and of the values of the error term for other cases.

3.3.6 The procedure for the pressure and sensation tests

3.3.6.1 Test management

Based on the pilot test and estimation, the whole test on one subject will last about 1-2 hours. As discussed above, the subjects were selected from the university female students; therefore the management of subjects and time management are very important to the success of the tests.

Firstly, based on the time table of this research, a time table of tests was made which give out the beginning time and time duration of every test. In order to guarantee enough time for every test, 2 hours for every test and half an hour gap between the two tests were employed. Secondly, this time table was shown to the potential subjects, the test procedure was introduced briefly to them, and then they were asked to choose the convenient time for them if they would like to do it. The name, the bra size, the mobile number and the e-mail

address were recorded at the same, this information is confidential and only used to select a suitable sample bra and make a contact with them. A sample of subjects registration form is shown in Appendix E. The subjects were also given the address of the place which the tests will be carried out. Thirdly, on the day before the test day, e-mail and mobile message reminders were sent to the subjects to remind them of the tests.

3.3.6.2 The procedure for the pressure and sensation tests

For every single test, there are 7 steps described below; a detailed procedure and data record form are shown in Appendix F and Appendix G.

(1) The introduction of the tests

(2) Answering the questionnaire

(3) The measurement of the breasts and the selection of sample bra

(4) The measurement of pressures

(5) The evaluation of sensations

(6) Photo taking

(7) Acknowledgement to the subject

The flow chart of a single test is shown in Figure 3.9, the flow chart of the whole pressure and sensation tests is shown in Figure 3.10.

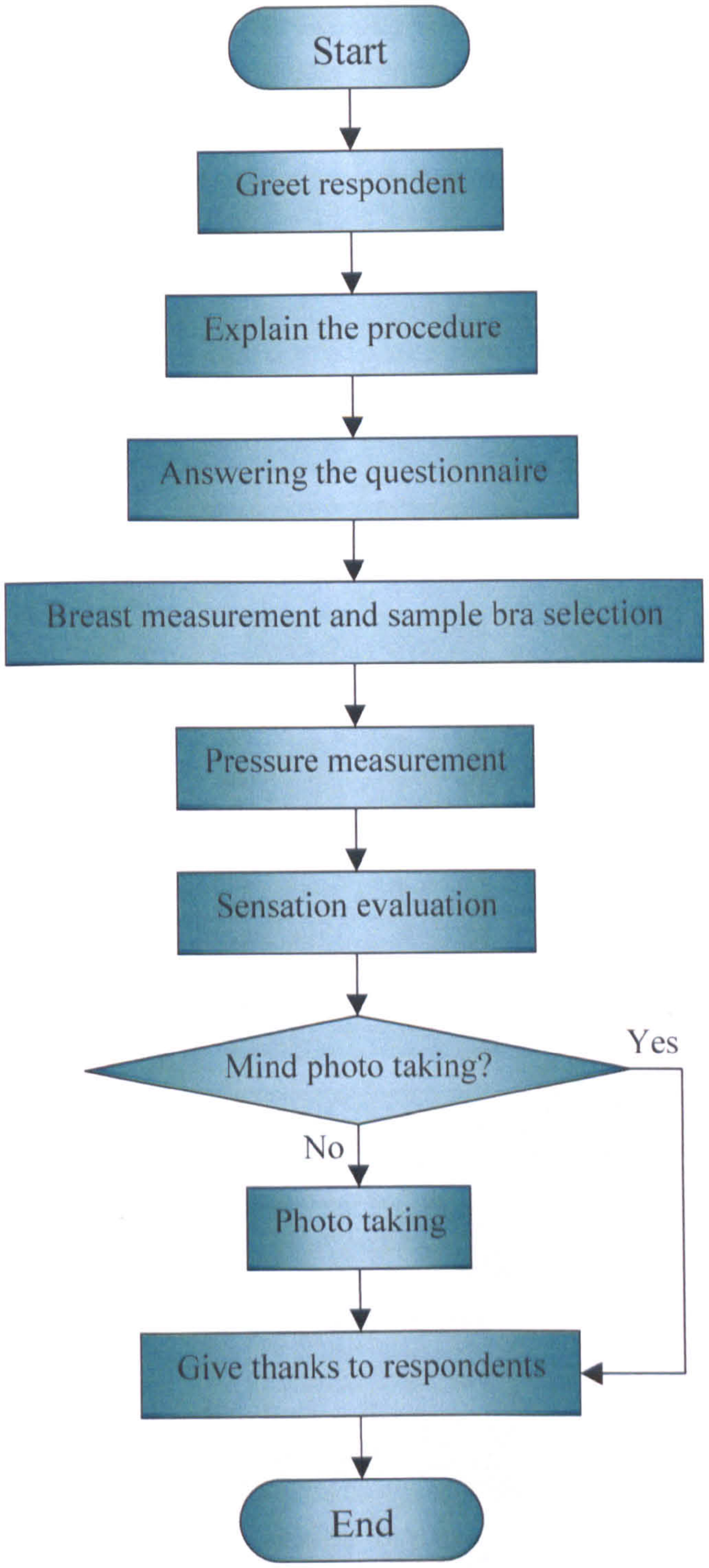


Figure 3.9 The flow chart of the procedure for a single test

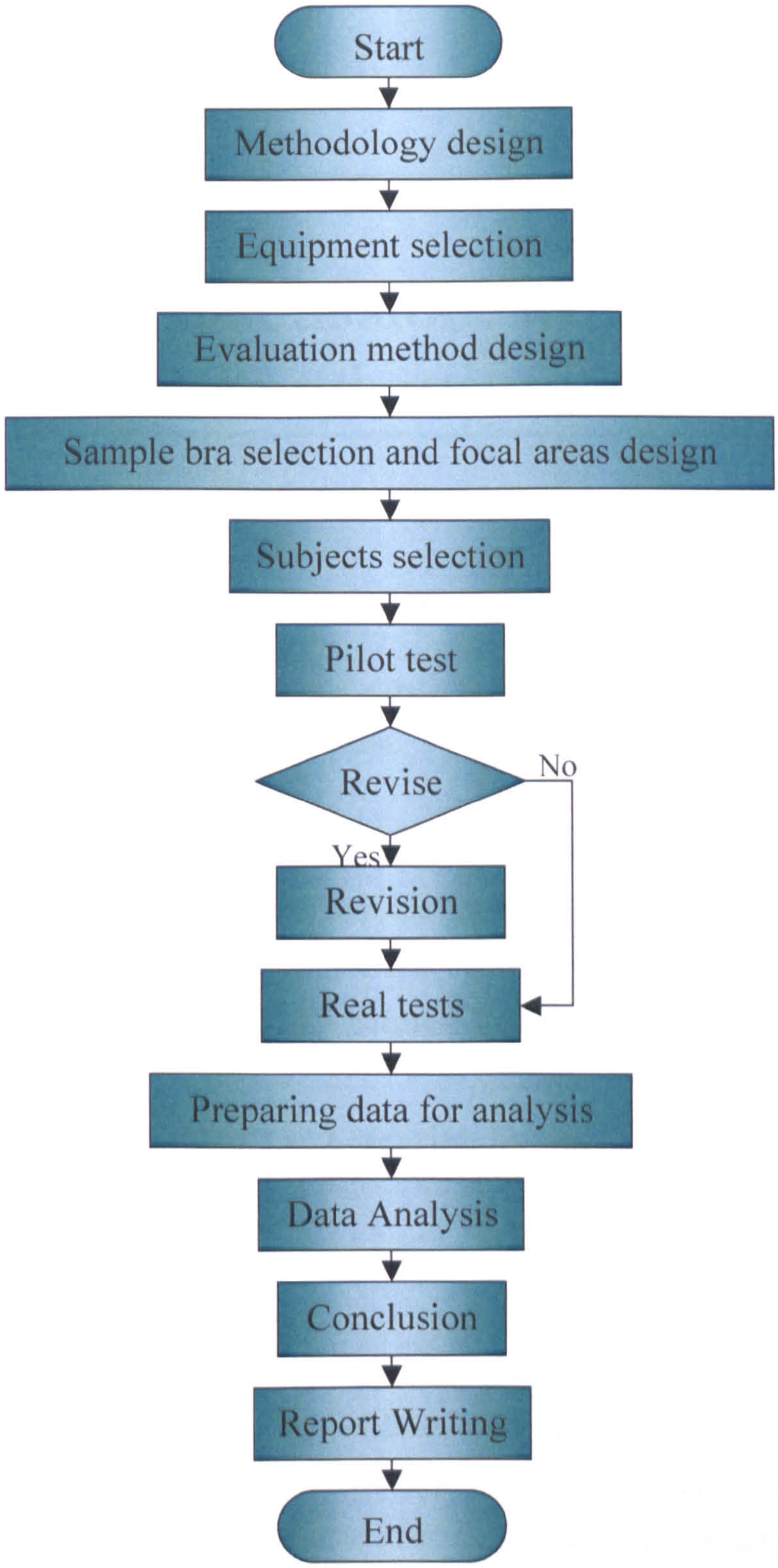


Figure 3.10 The flow chart of the whole tests

Chapter Four
Results and discussion: women's bra wearing habits and attitudes

4.1 Introduction

This chapter is to carry out in analysis and discussion of some issues related with women's bra wearing habits, attitudes and breast health.

The analytic procedure was applied into 3 different categories, namely the frequency analysis of the responses from the multi-choice questions, the analysis of the correlations amongst responses, and lastly, a comparison between the results from White-British respondents and those from Chinese respondents to find similarities and contrasts.

4.2 Basic analysis of women's bra wearing habits

4.2.1 Description of the questionnaire

The respondents of the survey were mostly selected from De Montfort University, the data collection method for this part of respondents were carried out individually. For the respondents from China, good contacts have been made before sending the questionnaires to respondents. Therefore, the response rate of this survey is quite high, about 98%.

Based on the designed sample size, the total number of returned questionnaire is 298.

As explained in Section 3.2.4.1, there are 6 types of questionnaire, which represent the different quality of the response, suggest where the missing answers are existed in the questionnaire. The number and percentage of different questionnaire types are shown in Table 4.1.

Table 4.1 The questionnaire type

Questionnaire type		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Fully answered	A	178	59.7	59.7	59.7
Partially answered	B	30	10.1	10.1	69.8
	C+	55	18.5	18.5	88.3
	C-	30	10.1	10.1	98.3
Unqualified answered	D	4	1.3	1.3	99.7
	E	1	0.3	0.3	100.0
Total		298	100.0	100.0	

As explained, the type A represents the fully answered questionnaires, 59.7% from the total number of questionnaire are fully answered questionnaire. The type B, C+, C- represent the questionnaires which have missing answers in different questions, but are qualified questionnaires and the data should be included into the analysis. The type D and E represents not-qualified questionnaires, the data will not be analysed in this study. The total percentage of qualified questionnaires of type A, B, C+, and C- is 98.3%, it means the response of this survey is sufficient.

4.2.2 Description of the respondents

4.2.2.1 Age and ethical origin

A distribution of respondents' age is shown in Table 4.2; the age from 16 to 40 occupies 88.9% of the respondents. Women in this age group are the main bra consumers; therefore, the data based on this age group should provide some meaningful results to improve bra fittings and design.

Table 4.2 The distribution of age

Age of respondents		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	16-20	111	37.2	37.5	37.5
	21-25	77	25.8	26.0	63.5
	26-30	36	12.1	12.2	75.7
	31-35	22	7.4	7.4	83.1
	36-40	17	5.7	5.7	88.9
	40-45	19	6.4	6.4	95.3
	46-50	6	2.0	2.0	97.3
	51-55	5	1.7	1.7	99.0
	56-60	2	0.7	0.7	99.7
	61 and over	1	0.3	0.3	100.0
	Total	296	99.3	100.0	
Missing		2	.7		
Total		298	100.0		

Table 4.3 showed that most of the respondents are White-British, occupy 66.1% of all the respondents. The Chinese respondents, as a comparison group, occupy 21% of the respondents. It reveals these results are more beneficial to White-British and Chinese women.

Table 4.3 The distribution of ethical origin

Ethical origin of respondents		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	White - British	195	65.4	66.1	66.1
	Chinese	62	20.8	21.0	87.1
	Other	38	12.8	12.9	100.0
	Total	295	99.0	100.0	
Missing		3	1.0		
Total		298	100.0		

4.2.2.2 Body shape

The data of respondents' weight and height were obtained from the questionnaire; a new variable of Body Mass Index (BMI) was calculated to evaluate the body shape of the respondents.

Body mass index is a relationship between weight and height that is associated with body fat and health risk. The equation used to calculate body mass index is as follows: Body Mass Index = Weight in kilograms / (Height in meters)^2.

There is lack of standard classification of health using BMI because different health organizations have their own standard. The National Heart, Lung, and Blood Institute propose the following classifications of health using body mass index as shown in Table 4.4. This classification was used as a reference, but the classification of BMI in this research is not exactly the same as Table 4.4.

Table 4.4 BMI classifications

Body Mass Index	Classification
Less than 18.5	Underweight
18.5 to 24.9	Normal
25.0 to 29.9	Overweight
30.0 to 34.9	Obese Class I
35.0 to 39.9	Obese Class II
40.0 or greater	Extremely Obese

The BMI distribution of the respondents from the survey is shown in Table 4.5.

From Table 4.5, it is shown that most of the respondents are within the normal weight, but there are about 19.3% of respondents, which have BMIs above 25, are overweight.

Table 4.5 The distribution of BMI

BMI category		Frequency	Percentage	Valid Percent	Cumulative Percentage
Valid	Below 18	4	1.3	1.7	1.7
	18-20	97	32.6	40.8	42.4
	21-24	91	30.5	38.2	80.7
	25-28	31	10.4	13.0	93.7
	29-32	10	3.4	4.2	97.9
	33 and over	5	1.7	2.1	100.0
	Total	238	79.9	100.0	
Missing		60	20.1		
Total		298	100.0		

4.2.2.3 Bra size

Bra size is important information for this study. From the survey, the bra size of every respondent was obtained (e.g. 34B), for the need of analysis, this data was transferred into 3 variables, namely bra back size (e.g. 34), bra cup size (e.g. B) and bra size (e.g. 34B). The size distribution of the respondents is shown in Table 4.6.

Table 4.6 The distribution of bra sizes

Bra back size / Bra cup size	Distribution of the respondents									Total
	30	32	34	36	38	40	42	Over 46	Below 30	
AA	0	0	2	0	0	0	0	0	1	3
A	0	8	23	5	4	1	0	0	0	41
B	0	22	42	19	6	0	0	0	0	89
C	0	15	28	20	5	1	1	1	0	71
D	1	13	11	7	6	1	0	0	0	39
DD	0	5	12	5	1	5	4	0	0	32
E	1	1	1	0	2	0	1	0	0	6
F	0	1	2	2	0	0	0	1	0	6
G	0	0	0	1	0	0	0	0	0	1
Total	2	65	121	59	24	8	6	2	1	288

The data from Table 4.6 shows a variety of bra sizes, it guaranteed the applicability of the results to most of the women. Most of the back sizes are within 32 to 38, and most of the cup sizes are within A to DD, the maximum number of bra sizes for the respondents is 34B.

4.2.3 Women's bra wearing habits

4.2.3.1 A general description of women's bra wearing habits.

This part include three questions,

Q.5. Do you wear a bra during your daily life, please select an option that best describes your wearing habits about bras.

Q.6. How long do you wear a bra during a day?

Q.7. When did you begin to wear a bra?

Table 4.7 The distribution of bra wearing habit

Bra wearing habit		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Wearing a bra at all times including sleeping hours	23	7.7	7.8	7.8
	Wearing a bra during waking hours	239	80.2	81.6	89.4
	Only wearing a bra outside the home	27	9.1	9.2	98.6
	Only wearing a bra in some special occasions	1	0.3	0.3	99.0
	Only wearing bra occasionally	1	0.3	0.3	99.3
	Never wearing bra	1	0.3	0.3	99.7
	other	1	0.3	0.3	100.0
	Total	293	98.3	100.0	
Missing		5	1.7		
Total		298	100.0		

From Table 4.7, a percentage of 81.6% reveals that most of the respondents are wearing a bra during waking hours, the average time of wearing a bra during a day is 14.41 hours, and most of the respondents began to wear a bra at their age of 11 to 14, the average age is 13.

4.2.3.2 The owned bras.

There are 3 questions in this part.

Q.9. Approximately how many bras do you own?

Q.10. Approximately how many new bras have you gained (including purchased and gifts) in the last year?

Q.11. On average, how soon will you discard a bra after your first wearing?

The results provide the information of the owned bra for women and a bra's life. From Table 4.8, Table 4.9 and Table 4.10, it is shown that most of the respondents own 6-10 bras for their daily life, most of the respondents will buy 3-5 new bras every year, and, in average, a bra's life is 9 months to 1.5 year. But there are still quite a lot of respondents, about 20%, are keeping a bra more than 2 years.

Table 4.8 Numbers of owned bra

Numbers of owned bra		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	0-5	51	17.1	17.3	17.3
	6-10	156	52.3	52.9	70.2
	11-15	52	17.4	17.6	87.8
	16-20	23	7.7	7.8	95.6
	21 and over	13	4.4	4.4	100.0
	Total	295	99.0	100.0	
Missing		3	1.0		
Total		298	100.0		

Table 4.9 Numbers of new bra for last year

Numbers of new bra for last year		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	0	7	2.3	2.4	2.4
	1-2	79	26.5	26.8	29.2
	3-5	152	51.0	51.5	80.7
	6-8	46	15.4	15.6	96.3
	9-12	8	2.7	2.7	99.0
	13-15	2	0.7	0.7	99.7
	16 and over	1	0.3	0.3	100.0
	Total	295	99.0	100.0	
Missing		3	1.0		
Total		298	100.0		

Table 4.10 Time of discarding a bra

Time of discarding a bra		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Within 1 month	1	.3	.3	.3
	2-3 months	9	3.0	3.1	3.5
	4-6 months	25	8.4	8.7	12.1
	7-9 months	36	12.1	12.5	24.6
	9-12 months	61	20.5	21.1	45.7
	1-1.5 years	64	21.5	22.1	67.8
	1.5-2 years	36	12.1	12.5	80.3
	2 years and over	57	19.1	19.7	100.0
	Total	289	97.0	100.0	
Missing		9	3.0		
Total		298	100.0		

4.2.3.3 Bra wearing habit related to exercise.

The question is:

Q.12. Do you wear a bra when you are doing exercise? If yes, which kind of bra do you wear when doing exercise? If no, can you specify the reasons?

From Table 4.11 and Table 4.12, it is discovered that 96.2% of the respondents are wearing a bra when doing exercise, among them, just 34% are wearing a sports bra, a large amount of 55% of the respondents are wearing the same bra as wearing in their daily life, and another 10% of the respondents are just wearing a bra during extreme exercise. The results show that the sports bra are not as popular as expected, most of the women are still wearing normal bras when doing exercises.

Among the few respondents who are not wearing a bra when doing exercise, most of them like to wear a tight vest during exercise, some of them are not doing exercises at all.

Table 4.11 Wearing a bra when doing exercise

Wearing a bra when doing exercise		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	No	11	3.7	3.8	3.8
	Yes	279	93.6	96.2	100.0
	Total	290	97.3	100.0	
Missing		8	2.7		
Total		298	100.0		

Table 4.12 The kind of bra wearing when doing exercise

The kind of bra wearing when doing exercise		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	The same bra as wearing for normal life	148	49.7	55.4	55.4
	Sports bra	91	30.5	34.1	89.5
	Only a sports bra during extreme exercise	27	9.1	10.1	99.6
	Other	1	0.3	0.4	100.0
	Total	267	89.6	100.0	
Missing		31	10.4		
Total		298	100.0		

4.2.3.4 Different sized bras

The question is

Q.14. Have you experienced wearing different sized bras? If yes, why do you wear different sized bras?

From Table 4.13 and Table 4.14, a large number of respondents, about 69.5%, have experienced wearing different sized bras, it means that the bra size for most of the women are not always the same during their daily life. The most common reasons of why they wear different sized bra are the existing small discrimination among styles and brands, and the change of body shape and weight. Another reason is some women can not find the bra exactly for their size, and have to try different sized bras. The result reveals that the bra size is not the only and correct way for women to select a suitable bra, other methods should be explored in the bra fitting issues.

Table 4.13 Wearing different sized bra

Wearing different sized bra		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	No	89	29.9	30.5	30.5
	Yes	203	68.1	69.5	100.0
	Total	292	98.0	100.0	
Missing		6	2.0		
Total		298	100.0		

Table 4.14 Reasons for wearing different sized bra

Reasons for wearing different sized bra	Numbers of responses	Percentage of responses
Discrimination among style and brands	146	51.8
Change of body shape and weight	106	37.6
Pregnancy	24	8.5
Breast surgery	1	0.4
Other	5	1.8
Total	282	100.0

4.2.4 Medical problems

The questions are:

Q.13. Have you had any medical problems with your breasts? If Yes, Does it influence your bra selection, wearing habits of bra or other things connected with bras? Can you specify how?

Q.16. Do you think wearing a bra can increase or reduce the chance of having breast health problems?

From Table 4.15, there are 22 respondents, about 7.5%, reported that they have experienced some medical problems with their breasts. Among them, half of the respondents reported that medical problems would influence their bra selection and wearing habits. From the answers of how it will influence their bra selection, one common reason is that medical problems restrict their bra selection; they can only wear a specific style of bra, such as padded, moulded or T-shirt bra. Another reason is that they have to pay more attention to the size of the bra and try to wear bras with therapy functions.

Table 4.15 Medical problems with breasts

Medical problems with breasts		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	No	271	90.9	92.5	92.5
	Yes	22	7.4	7.5	100.0
	Total	293	98.3	100.0	
Missing		5	1.7		
Total		298	100.0		

It is shown form Table 4.16 that a small number of the respondents don't care if wearing a bra can cause breast health problems to them, but most of the respondents care about it. Among the respondents who care about the breast health problems, 55.7% are not sure how a bra influence the breast health, 15.7% think it will increase the chance of having breast health problems by wearing a bra, and 19.9% think it will reduce the chance of having breast health problems by wearing a bra. Therefore the results showed that, actually,

women do care if it is good for their health to wear a bra, but they don't know much about the healthy issues relating to bras. It is essential more research relevant to the bras and breast health should be carried out to provide more information to women.

Table 4.16 The Chance of having breast health problems by wearing a bra

The chance of having breast health problems of wearing a bra		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Increase the chance	45	15.1	15.7	15.7
	Reduce the chance	57	19.1	19.9	35.5
	Don't care	25	8.4	8.7	44.3
	Not sure	160	53.7	55.7	100.0
	Total	287	96.3	100.0	
Missing		11	3.7		
Total		298	100.0		

4.2.5 Women's attitudes towards bra

The question is:

Q.15. Listed below are some statements about bras, please specify how strongly you agree or disagree with the following statements.

	Strongly agree	Agree	neutral	Disagree	Strongly disagree	Not sure
A bra is an IMPORTANT garment for women.	☐	☐	☐	☐	☐	☐
A bra is an ESSENTIAL garment for women.	☐	☐	☐	☐	☐	☐
A bra is a GOOD garment for women.	☐	☐	☐	☐	☐	☐
A bra can provide a fashionable shape to the breasts.	☐	☐	☐	☐	☐	☐
Some kinds of bras can distort the shape of the breasts.	☐	☐	☐	☐	☐	☐
Tighter bras can provide better breast shapes.	☐	☐	☐	☐	☐	☐
I think that not wearing a bra is more natural and more comfortable.	☐	☐	☐	☐	☐	☐

I prefer not to wear a bra.	☐	☐	☐	☐	☐	☐
I am wearing a bra just because it is socially correct, otherwise, I'd rather not wearing a bra.	☐	☐	☐	☐	☐	☐
A bra can provide support to the breasts.	☐	☐	☐	☐	☐	☐
Wearing a bra is more comfortable.	☐	☐	☐	☐	☐	☐
I'd like to sacrifice the comfort for an improvement of breast shape and support.	☐	☐	☐	☐	☐	☐
I am happy to improve my breast shape and support by wearing a bra using harmless NON-FABRIC materials, such as polymer and rubber.	☐	☐	☐	☐	☐	☐

According to the respondents' answers, these statements can be classified as follows:

Strongly agree:

A bra is an important garment for women.

A bra is an essential garment for women.

A bra can provide support to the breast.

Agree:

A bra is a good garment for women.

A bra can provide a fashionable shape to the breasts.

Some kinds of bras can distort the shape of breasts.

Wearing a bra is more comfortable.

Neutral:

I am happy to improve my breast shape and support by wearing a bra using harmless non-fabric materials, such as polymer and rubber.

Disagree:

Tighter bras can provide better breast shapes.

I think that not wearing a bra is more natural and more comfortable.

I'd like to sacrifice the comfort for an improvement of breast shape and support.

Strongly disagree:

I prefer not to wear a bra.

I am wearing a bra just because it is socially correct, otherwise, I'd rather not wearing a bra.

From the results, generally speaking, the respondents are holding a positive attitude towards bra. The respondents have a strong belief that a bra is an important and essential garment for women, and is also good for women in most circumstances. The respondents strongly prefer to wear a bra, not just because it is socially correct. The characteristics of bras which are strongly believed are providing supports and fashionable shapes to the breasts. The respondents also agree that badly designed bras can distort the shape of the breasts, but a tighter bra can provide a better breast shape. Most respondents pay a lot attention to the comfort property of the bra, it is agreed that wearing a bra is more comfortable, and it is so important that they don't want to sacrifice the comfort for an improvement of breast shape and support. The respondents don't mind using harmless non-fabric materials into bras to improve the breast shape and support.

4.2.6 Bra style and support

The questions are:

Q.17. What style of bras do you prefer? (Multi-selection)

Q.18. What kind of support of bras do you prefer?

Table 4.17 The bra styles

Styles	Numbers of responses	Percentage of responses
Non-padded underwired bra	118	16.7
Padded underwired bra	140	19.8
Soft non-padded bra	33	4.7
Soft padded bra	45	6.4
Balcony bra	91	12.9
Push up bra	71	10.0
Strapless bra	47	6.6
Soft fabric moulded bra	60	8.5
T-shirt bra	95	13.4
Other	8	1.1
Total	708	100.0

From Table 4.17, the bra styles can be put into sequence from the most preferred to the least preferred described below:

(1) Padded underwired bra

(2) Non-padded underwired bra

(3) T-shirt bra

(4) Balcony bra

(5) Push up bra

(6) Soft fabric moulded bra

(7) Strapless bra

(8) Soft padded bra

(9) Soft non-padded bra

(10) Other

It is shown that the underwired bras are the most favourite style to the respondents, and the soft bras are the least favourite. Table 4.18 shows that medium support bras are preferred by most of the respondents.

Table 4.18 The preferred support

Preferred support		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Full support	80	26.8	27.9	27.9
	Medium support	182	61.1	63.4	91.3
	Light support	25	8.4	8.7	100.0
	Total	287	96.3	100.0	
Missing		11	3.7		
Total		298	100.0		

4.2.7 Bra properties

The question is

Q.19. Listed below are some properties of bras, do you think which one is the most important, and which one is the least important? Please put these properties into number order from most important to least important.

The mean of each property were calculate, the results were shown in Table 4.19.

Table 4.19 The mean of each property

	N	Mean
Fit	271	1.98
Comfort	271	2.19
Quality	271	4.28
Material	271	5.21
Breast support	271	3.97
Price	271	6.55
Brand	271	8.04
Style	271	5.70
Color	271	7.08

Based on the value of means, the properties can be listed from the most important to the least important as below:

(1) Fit

(2) Comfort

(3) Breast support

(4) Quality

(5) Material

(6) Style

(7) Price

(8) Color

(9) Brand

From the list, it was discovered that women are paying more attention to the functional properties of the bras, such as fit, comfort, support, quality and material, than the

appearance properties as style, price, color and brand. Therefore the functional properties of the bras should be considered as important factors in bra fitting and design.

4.2.8 Reported satisfaction with a bra

The questions are:

Q.20. Do you satisfied with the existing bra products in both retail and mail order? If not, please specify the reasons.

Q.21. Can you always find a perfect fit bra? If not, according to Figure 4.1, please specify which parts of the bra are mostly difficult to fit your breasts.

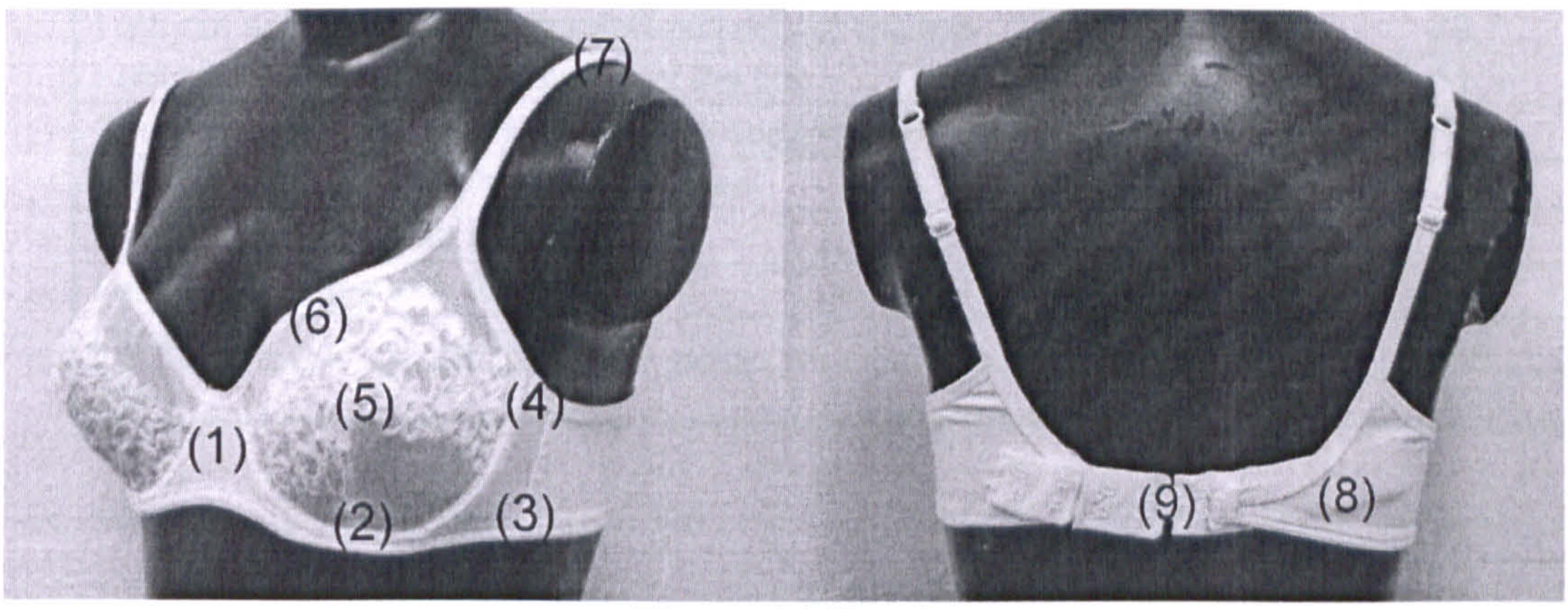


Figure 4.1 Focal areas

From Table 4.20, it is shown that 60.6% of the respondents are satisfied with the existing bras, but there are still quite a lot of respondents, about 39%, are not satisfied with the existing bras.

Table 4.20 Satisfaction of existing bras

Satisfaction of existing bra		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	No	114	38.3	39.4	39.4
	Yes	175	58.7	60.6	100.0
	Total	289	97.0	100.0	
Missing		9	3.0		
Total		298	100.0		

There are some reasons of dissatisfaction with the existing bras, it was discovered that the most common reasons are that a right size or a good comfort are not easy to be achieved. Therefore the bra size and the bra comfort property are the two important factors which should be paid more attention to in the bra fitting and design.

Table 4.21 Reasons of dissatisfaction with the existing bras

Reasons of dissatisfaction with the existing bras	Numbers of responses	Percentage of responses
I can not find my size	60	25.9
I am not satisfied with the comfort property of the bra	48	20.7
I am not satisfied with the quality of the bra	26	11.2
The existing bra can not offer enough support to my size	21	9.1
I am not satisfied with the material used	22	9.5
I am not satisfied with the style	28	12.1
I am not satisfied with the color	14	6.0
Other	13	5.6
Total	232	100.0

Table 4.22 shows that 73.8% of the respondents are agreed that they can not always find a perfect fit bra.

Table 4.22 Always find a perfect fit bra

Always find a perfect fit bra		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	No	214	71.8	73.8	73.8
	Yes	76	25.5	26.2	100.0
	Total	290	97.3	100.0	
Missing		8	2.7		
Total		298	100.0		

Form Table 4.23, it was discovered that the area which is most hard to fit in the bra is Area 6, which is the centre neck edge of the bra. Besides, Area 4, the upper underarm, is also a hard-to-fit area. Therefore it means the fit of the bra is a problem of the existing bras, the

information of the hard-to-fit areas in the bra from this study may provide some reference to the bra fitting and design process.

Table 4.23 The hard-to-fit areas

Areas	Numbers of responses	Percentage of responses
Area 1	59	12.9
Area 2	45	9.8
Area 3	17	3.7
Area 4	77	16.8
Area 5	62	13.6
Area 6	104	22.8
Area 7	44	9.6
Area 8	24	5.3
Area 9	25	5.5
Total	457	100.0

4.3 Correlation among responses

The above analysis has answered part of the research questions proposed in the survey design, but it has not discovered the correlations amongst the respondent's responses. In this section, the correlation analysis was used to discover the correlations between two responses, it will answer the research question of 'Are there any relationships amongst women's wearing habits, women's attitudes to bra and demographic characters?'.

4.3.1 Correlations among respondents' demographic characteristics

Use correlation analysis, results were obtained as shown in Table 4.24. Words in the column of the far right side of the table, titled Explanation, explain the meaning of the data in every row. In order to save spaces, this column will not appear in the following similar tables from Table 4.25 to Table 4.33.

Table 4.24 Correlations among respondents' demographic characteristics

Correlations among respondent' demographic characteristics								
	Age	Height	Weight	BMI	Bra back size	Bra cup size	Bra size	Explanation
Age	1.000 . 296							Correlation Coefficient Significance N
Height	-0.227 (**) 0.000 286	1.000 . 288						Correlation Coefficient Significance N
Weight	0.093 0.155 237	0.391 (**) 0.000 238	1.000 . 239					Correlation Coefficient Significance N
BMI	0.211 (**) 0.001 236	-0.121 0.062 238	0.838 (**) 0.000 238	1.000 . 238				Correlation Coefficient Significance N
Bra back size	0.329 (**) 0.000 290	0.094 0.114 283	0.553 (**) 0.000 234	0.538 (**) 0.000 233	1.000 . 292			Correlation Coefficient Significance N
Bra cup size	-0.071 0.233 286	-0.061 0.309 279	0.364 (**) 0.000 231	0.378 (**) 0.000 230	0.111 0.059 288	1.000 . 288		Correlation Coefficient Significance N
Bra size	0.265 (**) 0.000 286	0.079 0.188 279	0.629 (**) 0.000 231	0.630 (**) 0.000 230	0.932 (**) 0.000 288	0.386 (**) 0.000 288	1.000 . 288	Correlation Coefficient Significance N

** Correlation is significant at the 0.01 level (2-tailed).

From Table 4.24, information of correlations among respondents' demographic characteristics was obtained as follows:

(1) The correlations between the age and other factors are not so significant.

(2) There is a positive correlation between the height and the weight (0.391); correlations between the height and other factors are not very distinct.

(3) There is a strong positive correlation between the weight and the BMI (0.838); it means that, about the two factors of BMI, the weight influences the value of the BMI much more than the height.

(4) There is a strong positive correlation between the weight and the bra back size (0.553), the correlation between the weight and the bra cup size (0.364) is also significant, but not so strong. A strong positive correlation between the weight and the bra size (0.629) means where there is a heavier body weight; there is a bigger bra size.

(5) Due to the significant correlation between the weight and the BMI, the weight and the bra size, there is also a strong positive correlation between the BMI and the bra size (0.630), it means where there is a plumper body shape, and there is a bigger bra size.

4.3.2 Correlations relating to bra wearing habits

From Table 4.25, a significant positive correlation of 0.157 means that the respondents who have larger bra cup sizes tend to wear bras for a longer time during a day, it is probably because women with large breasts require the support of bras for a longer time. The age of beginning to wear a bra has a significant negative correlation with the bra cup size (-0.393) and the bra back size (-0.117), this means the respondents who begin to wear bras at earlier ages tend to have larger bra sizes, especially larger cup sizes. A significant negative correlation (-0.149) between the hours of wearing a bra during a day and the age of beginning to wear a bra reveals that the respondents who begin to wear bras at earlier ages tend to wear bras for a longer time during a day.

Table 4.25 Correlations relating to bra wearing habits

Correlations relating to bra wearing habits		
	Hours of wearing a bra during a day	Age of beginning to wear a bra
Age	-0.071 0.228 288	0.283(**) 0.000 288
Height	-0.049 0.415 280	-0.135(*) 0.024 280
Weight	0.028 0.666 233	-0.289(**) 0.000 233
Bra back size	-.0046 0.435 287	-0.117(*) 0.047 287
Bra cup size	0.157(**) 0.008 284	-0.393(**) 0.000 283
Hours of wearing a bra during a day	1.000 . 290	-0.149(*) .012 287
Age of beginning to wear a bra		1.000 . 290

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 4.26 shows that there are weak significant negative correlations between the age and the numbers of owned bras (-0.180), and the age and the numbers of new bras (-0.119); this means that the younger women probably own more bras and buy more new bras than older women. A positive significant correlation between the numbers of owned bras and the numbers of new bras (0.433) and a negative significant correlation between the numbers of new bras and the time of discarding a bra (-0.232) reveal that those who owned more bras tend to buy more new bras, and those who buy more new bras tend to discard a bra sooner than others.

Table 4.26 Correlations relating to owned bras

Correlations relating to owned bras			
	Numbers of owned bra	Numbers of new bra for last year	Time of discarding a bra
Age in years	-0.180(**) 0.002 293	-0.119(*) 0.042 293	-0.064 0.278 287
Numbers of owned bra	1.000 . 295	0.433(**) 0.000 295	0.062 0.290 289
Numbers of new bra for last year		1.000 . 295	-0.232(**) 0.000 289
Time of discarding a bra			1.000 . 289

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

In Table 4.27, a weak significant positive correlation between the age and the medical problems with breasts means that the older respondents are more likely to have a medical problem with their breasts than younger respondents.

Table 4.27 the correlation between age and medical problems

The correlation between age and medical problems	
	Medical problems with breasts
Age in years	0.190(**) 0.001 291

** Correlation is significant at the 0.01 level (2-tailed).

4.3.3 Correlations relating to bra styles

In Table 4.28, the preference of bra styles has a significant correlation with the age. A positive significant correlation (0.260) means that older respondents prefer non-padded underwired bras, but younger respondents have a strong preference to padded underwired bras, balcony bras and push up bras. Younger respondents also like strapless and T-shirt bras more than older respondents. This means that there are different preferences to bra styles based on different age groups.

Table 4.28 Correlations relating to bra styles

Correlations between bra styles and respondents' demographic characteristics					
	Age	Height	Weight	Bra back size	Bra cup size
Non-padded underwired bra	0.260(**) 0.000 292	-0.072 0.226 284	0.085 0.193 235	0.137(*) 0.019 291	0.207(**) 0.000 287
Padded underwired bra	-0.329(**) 0.000 292	0.128(*) 0.032 284	-0.049 0.453 235	-0.183(**) 0.002 291	-0.184(**) 0.002 287
Soft non-padded bra	0.111 0.058 292	-0.040 0.498 284	-0.044 0.498 235	0.053 0.363 291	-0.087 0.140 287
Soft padded bra	-0.015 0.799 292	-0.113 0.056 284	-0.123 0.061 235	-0.002 0.979 291	-0.138(*) 0.019 287
Balcony bra	-0.282(**) 0.000 292	0.009 0.877 284	0.027 0.685 235	-0.094 0.110 291	0.091 0.122 287
Push up bra	-0.231(**) 0.000 292	-0.017 0.774 284	-0.184(**) 0.005 235	-0.141(*) 0.016 291	-0.097 0.102 287
Strapless bra	-0.146(*) 0.013 292	-0.031 0.604 284	-0.171(**) 0.009 235	-0.071 0.228 291	-0.081 0.170 287
Soft fabric moulded bra	0.024 0.681 292	0.097 0.104 284	-0.009 0.890 235	0.079 0.177 291	-0.100 0.090 287
T-shirt bra	-0.167(**) 0.004 292	0.095 0.112 284	0.041 0.527 235	-0.082 0.163 291	0.017 0.771 287

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The preference of bra styles also has some correlations with the respondents' bra sizes. From Table 4.28, it is shown that the respondents who have bigger bra back and cup sizes tend to prefer non-padded underwired bras, but smaller sized respondents prefer padded underwired bras, soft padded bras and push-up bras. This reflects that woman have an intention to make the breasts look bigger and plumper with the aid of a suitable style of bras.

Table 4.29 shows that there are correlations among preferred styles, which means the respondents who prefer this style tend to, or tend not to prefer another style.

Based on the data from Table 4.29, the correlations can be divided into pairs as follows:

(1) The group of bra styles for respondents who prefer one of the styles, tend to prefer another styles

Padded underwired bra, balcony bra, pushes up bra and strapless bra

Padded underwired bra and T-shirt bra

Balcony bra and T-shirt bra

Push up and T-shirt bra

Strapless bra and soft fabric moulded bra

Soft fabric moulded bra and T-shirt bra

(2) Bra styles against each other for respondents who prefer this style tend not to prefer another style

Non-padded underwired bra and padded underwired bra

Non-padded underwired bra and soft padded bra

Non-padded underwired bra and push up bra

Padded underwired bra and soft non-padded bra

Soft non-padded bra and T-shirt bra

Table 4.29 The correlations among preferred styles

Correlations among preferred bra styles									
	Non-padded underwired bra	Padded underwired bra	Soft non-padded bra	Soft padded bra	Balcony bra	Push up bra	Strapless bra	Soft fabric moulded bra	T-shirt bra
Non-padded underwired bra	1.000 . 294								
Padded underwired bra	-0.406 (**) 0.000 294	1.000 . 294							
Soft non-padded bra	-0.071 0.223 294	-0.166 (**) 0.004 294	1.000 . 294						
Soft padded bra	-0.117 (*) 0.045 294	0.011 0.854 294	0.028 0.628 294	1.000 . 294					
Balcony bra	-0.038 0.518 294	0.172 (**) 0.003 294	-0.005 0.932 294	-0.060 0.306 294	1.000 . 294				
Push up bra	-0.122 (*) 0.037 294	0.337 (**) 0.000 294	-0.050 0.397 294	0.025 0.669 294	0.224 (**) 0.000 294	1.000 . 294			
Strapless bra	0.003 0.965 294	0.179 (**) 0.002 294	0.021 0.716 294	0.072 0.216 294	0.250 (**) 0.000 294	0.383 (**) 0.000 294	1.000 . 294		
Soft fabric moulded bra	0.085 0.148 294	0.058 0.322 294	0.034 0.563 294	0.043 0.467 294	0.081 0.167 294	0.069 0.237 294	0.217 (**) 0.000 294	1.000 . 294	
T-shirt bra	-0.106 0.070 294	0.157 (**) 0.007 294	-0.200 (**) 0.001 294	0.110 0.059 294	0.182 (**) 0.002 294	0.154 (**) 0.008 294	0.056 0.340 294	0.155 (**) 0.008 294	1.000 . 294

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

These correlations reflect women's preference to bra styles and the relationships among styles, this information may be useful to the bra manufacturers and designers.

4.3.4 Correlations relating to preferred support

The data in Table 4.30 shows that there are significant negative correlations between the preferred support and the bra size; it means that the respondents who have bigger bra sizes tend to prefer more support. Especially to the big cup sized respondents, a strong negative correlation (-0.474) shows that they need more support to their breasts by wearing the bras.

Table 4.30 Correlations relating to preferred support

Correlations between preferred support and respondents' demographic characteristics					
	Age	Height	Weight	Bra back size	Bra cup size
Preferred support	0.047 0.426 285	0.029 0.632 277	-0.110 0.094 233	-0.203(**) 0.001 284	-0.474(**) 0.000 280

** Correlation is significant at the 0.01 level (2-tailed).

4.3.5 Correlation relating to bra properties

From the data in Table 4.31, it is shown that the older respondents tend to pay more attention to the material and the brand than the younger respondents, but pay less attention to the style. The heavier and bigger cup sized respondents tend to look on breast support as an important factor than lighter and smaller cup sized respondents; this information proved that the bigger sized women require more support to their breasts from wearing bras.

Table 4.31 Correlations relating to bra properties

Correlations between bra properties and respondents' demographic characteristics					
	Age	Height	Weight	Bra back size	Bra cup size
Fit	0.020 0.743 270	0.040 0.522 264	0.043 0.518 224	0.014 0.818 269	-0.072 0.244 266
Comfort	0.000 0.997 270	0.006 0.927 264	-0.071 0.291 224	-0.112 0.067 269	0.079 0.196 266
Quality	-0.018 0.770 270	0.005 0.930 264	0.116 0.084 224	0.061 0.320 269	0.018 0.764 266
Material	-0.206(**) 0.001 270	0.077 0.213 264	0.107 0.109 224	-0.061 0.317 269	0.234(**) 0.000 266
Breast support	0.141(*) 0.020 270	-0.051 0.413 264	-0.242(**) 0.000 224	-0.099 0.106 269	-0.275(**) 0.000 266
Price	-0.020 0.744 270	0.043 0.490 264	-0.051 0.449 224	-0.078 0.202 269	-0.007 0.907 266
Brand	-0.231(**) 0.000 270	0.015 0.814 264	-0.040 0.553 224	-0.157(*) 0.010 269	0.047 0.445 266
Style	0.163(**) 0.007 270	-0.058 0.349 264	0.023 0.735 224	0.222(**) 0.000 269	-0.086 0.161 266
Color	0.063 0.299 270	-0.059 0.342 264	0.089 0.182 224	0.158(**) 0.009 269	0.064 0.296 266

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

4.3.6 Correlations relating to the fit of the bra

From the data in Table 4.32, it is shown that some hard-to-fit areas have correlations with the age and the bra size. Older respondents reported Area 2, the centre underband, is harder to fit than younger respondents, but Area 6, the centre neck edge, is probably easier to fit. It

is probably because women in different ages have different shapes of breasts, it is better to design different patterns for women at different ages.

Table 4.32 Correlations relating to the fit areas of the bra

Correlations between the fit areas of the bra and the respondents' demographic characteristics					
	Age	Height	Weight	Bra back size	Bra cup size
Area 1	-0.131 0.057 212	-0.076 0.279 205	0.074 0.330 176	-0.174(*) 0.012 210	0.171(*) 0.013 209
Area 2	0.180(**) 0.009 212	-0.006 0.931 205	0.019 0.801 176	0.105 0.130 210	0.017 0.807 209
Area 3	0.078 0.259 212	-0.073 0.302 205	0.001 0.985 176	0.102 0.139 210	0.013 0.851 209
Area 4	-0.071 0.306 212	0.036 0.613 205	0.107 0.159 176	0.002 0.980 210	0.155(*) 0.025 209
Area 5	0.016 0.812 212	-0.129 0.065 205	-0.248(**) 0.001 176	-0.128 0.063 210	-0.201(**) 0.004 209
Area 6	-0.150(*) 0.029 212	0.001 0.983 205	-0.145 0.054 176	-0.082 0.237 210	0.047 0.499 209
Area 7	0.070 0.310 212	-0.039 0.578 205	0.017 0.820 176	0.080 0.251 210	0.001 0.984 209
Area 8	0.085 0.219 212	0.120 0.086 205	0.137 0.071 176	0.128 0.064 210	-0.008 0.910 209
Area 9	-0.052 0.455 212	-0.024 0.728 205	0.025 0.743 176	0.138(*) 0.047 210	0.007 0.924 209

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

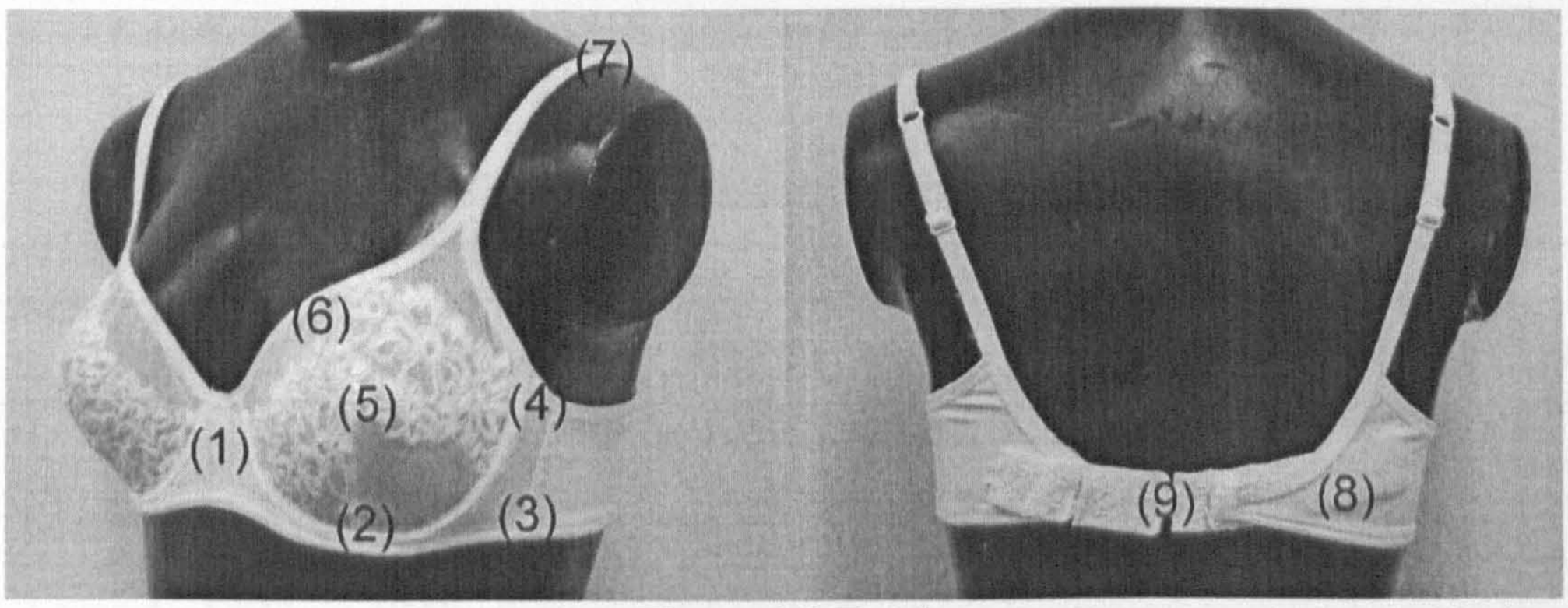


Figure 4.2 Focal areas

Area 5, the high point of bust, is an area which is hard to fit for lighter and smaller cup sized respondents. Area 1, the centre front, is easier to fit for bigger back sized respondents, but hard to fit for big cup sized respondents. A bigger cup sized respondent may report area 4, the upper underarm, is harder to fit, and a bigger back sized respondent may report area 9, the centre back, is harder to fit than smaller back sized respondents. It is probably because women with different bra sizes have different shapes of breast, it is better to design different patterns for women with different bra sizes.

Besides, there are also some correlations among hard-to-fit areas which are shown in Table 4.33. It was discovered that there are some areas which can be named as 'positive pairs', which means if this area is hard to fit, the other area is also hard to fit at the same time, and vice versa. There are also 'negative pairs', which means if this area is hard to fit, the other area is easy to fit. Such kinds of pairs are described below:

(1) Positive pairs:

Area 3 (lower underarm) and Area 4 (upper underarm)

Area 8 (wing back) and Area 9 (centre back)

(2) Negative pairs:

Area 1 (centre front) and Area 8 (wing back)

Area 2 (centre underband) and Area 5 (high point of bust)

Area 4 (upper underarm) and Area 5 (high point of bust)

Area 4 (upper underarm) and Area 6 (centre neck edge)

Table 4.33 Correlations among hard-to-fit areas

Correlations among hard-to-fit areas									
	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	1.000 . 212								
Area 2	-0.039 0.570 212	1.000 . 212							
Area 3	0.049 0.476 212	-0.068 0.322 212	1.000 . 212						
Area 4	0.078 0.257 212	-0.032 0.641 212	0.246 (**) 0.000 212	1.000 . 212					
Area 5	-0.122 0.077 212	-0.156 (*) 0.023 212	0.001 0.988 212	-0.184 (**) 0.007 212	1.000 . 212				
Area 6	-0.041 0.554 212	-0.002 0.980 212	-0.081 0.239 212	-0.211 (**) 0.002 212	0.074 0.281 212	1.000 . 212			
Area 7	-0.058 0.399 212	0.076 0.273 212	-0.065 0.343 212	-0.048 0.488 212	-0.099 0.151 212	-0.060 0.384 212	1.000 . 212		
Area 8	-0.222 (**) 0.001 212	-0.003 0.960 212	0.004 0.952 212	-0.053 0.441 212	-0.066 0.338 212	-0.053 0.444 212	0.001 0.992 212	1.000 . 212	
Area 9	-0.097 0.161 212	-0.011 0.874 212	0.054 0.438 212	-0.033 0.634 212	0.086 0.210 212	0-.037 0.592 212	-0.007 0.922 212	0.192 (**) 0.005 212	1.000 . 212

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

This information is quite useful to the bra pattern design process; it should be considered that if the revision of the pattern for one area of the bra will influence the fit of another area of the bra.

4.4 The comparison between the White-British respondents and Chinese respondents

In this survey, it is known that there are two main groups of respondents from different ethnic origins, one is White-British, and the other is Chinese. There are only a few respondents from other ethnic origin. By comparing the responses from these two main groups, it can be discovered if there exists any difference among respondents from different ethical origins.

By using Crosstabulation tables, Chi-square tests and comparing means, it was discovered that from most of the responses, there is no distinct difference between the White-British and Chinese, but there does exist differences in some of the responses, which was discussed in the following analysis.

4.4.1 Differences in the BMI and bra size

From Table 4.34, it is shown that the White-British is a bit taller and heavier than Chinese, so is the body mass indices.

About the bra size, from Figure 4.3 and Figure 4.4, it is shown that there is not so much difference between the White-British respondents and the Chinese respondents in bra back size, but there is not a big range of cup sizes for the Chinese respondents and there is an inclination to smaller cup sizes for the Chinese respondents.

Table 4.34 Differences in the BMI

Ethnic origin		Height in centimetres	Weight in kilograms	Body mass indices
White - British	Mean	165.22	61.59	22.68
	N	189	152	152
	Std. Deviation	6.808	10.558	3.841
Chinese	Mean	161.55	52.36	20.05
	N	62	61	61
	Std. Deviation	5.659	6.563	2.093
Total	Mean	164.31	58.95	21.93
	N	251	213	213
	Std. Deviation	6.723	10.444	3.628

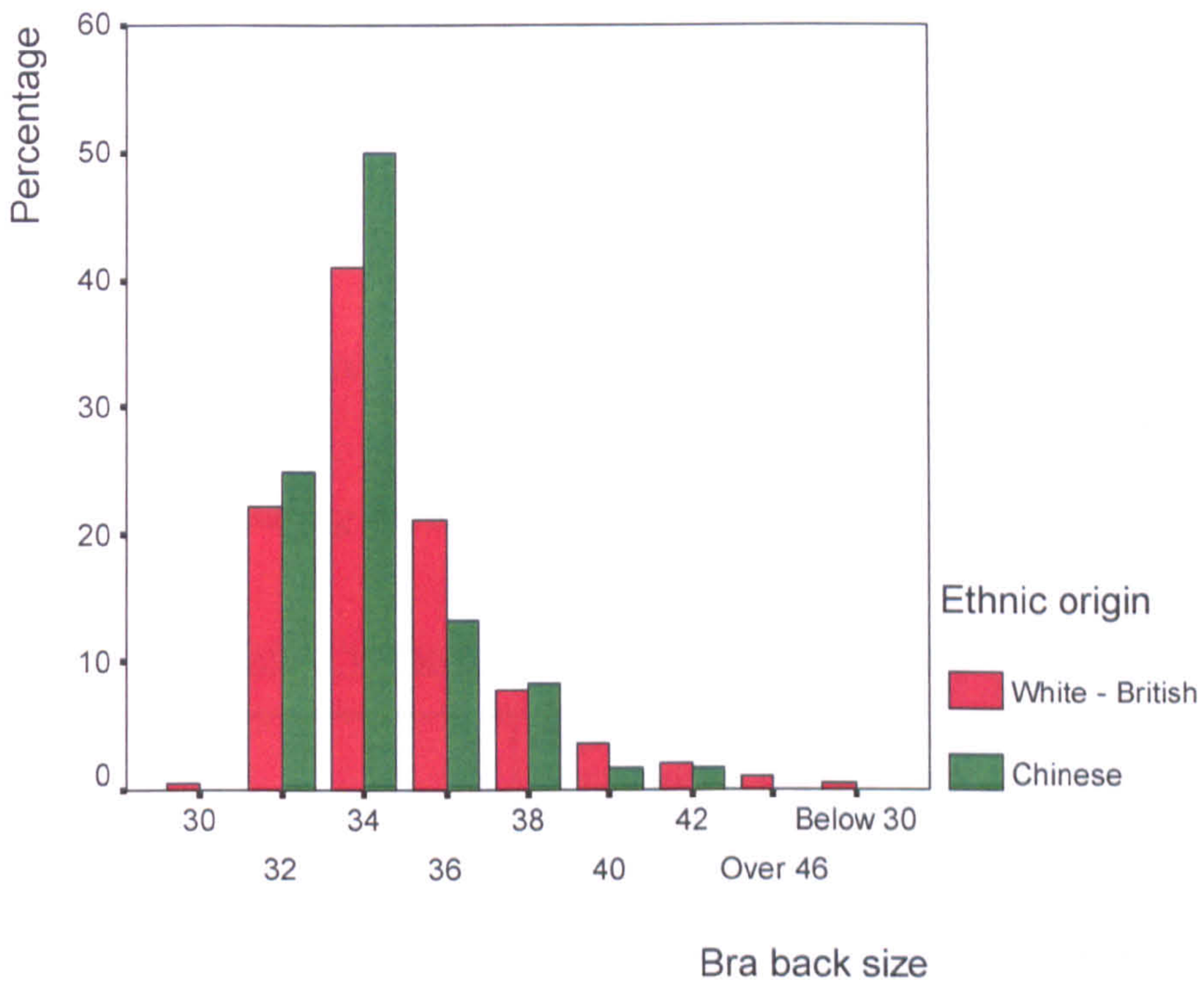


Figure 4.3 Differences in bra back size

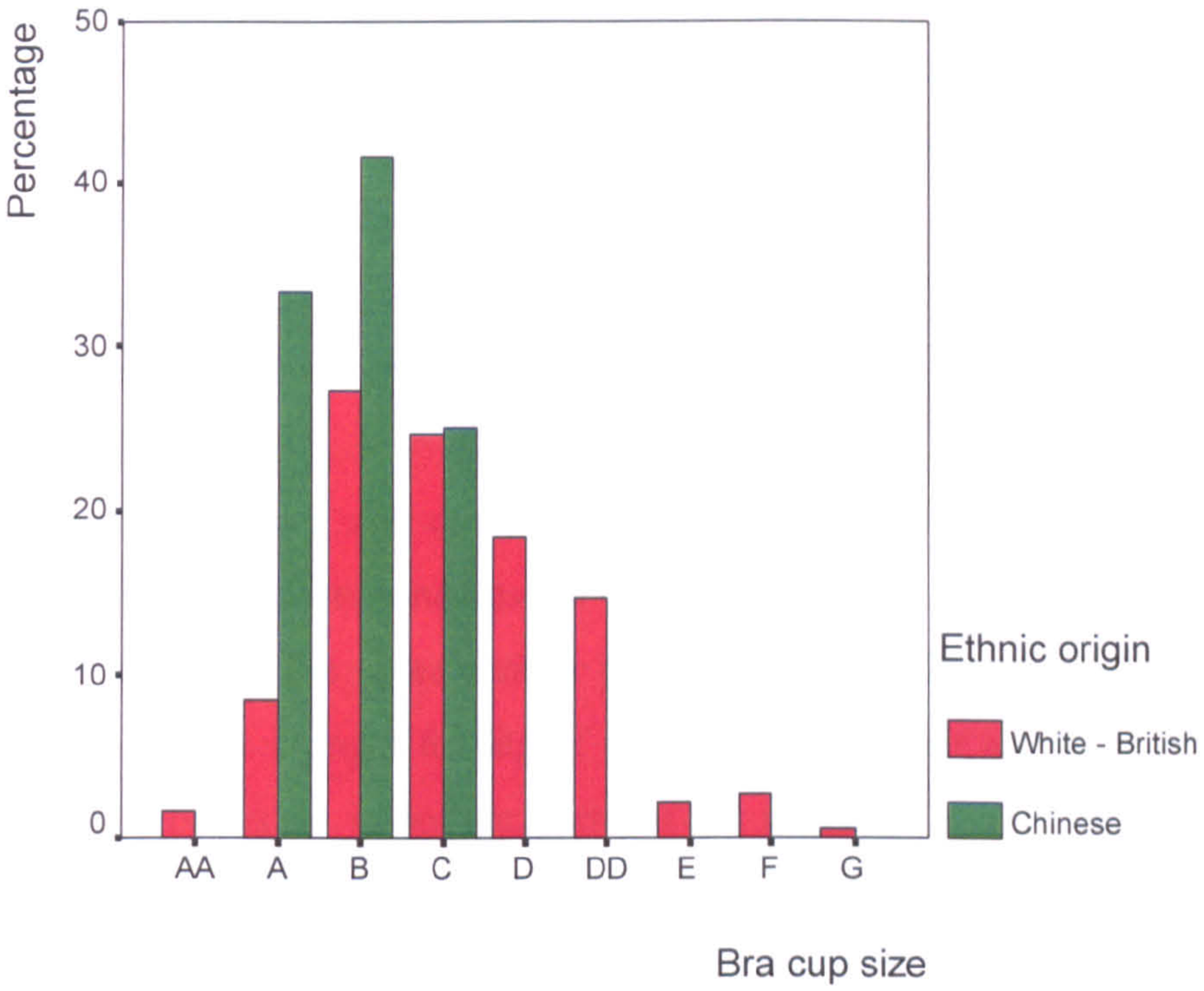


Figure 4.4 Differences in bra cup size

4.4.2 Differences in bra wearing habits

Table 4.35 Differences in bra wearing habit

Ethnic origin		Hours of wearing a bra during a day	Age of beginning to wear a bra
White - British	Mean	14.30	12.49
	N	191	193
	Std. Deviation	2.827	1.335
Chinese	Mean	13.74	15.64
	N	62	61
	Std. Deviation	4.081	2.381
Total	Mean	14.16	13.25
	N	253	254
	Std. Deviation	3.180	2.124

Table 4.35 shows that the White-British respondents wear a bra for a little longer time than the Chinese respondents every day. The White-British respondents start wearing a bra about 3 years earlier than the Chinese respondents; it is probably because the White-British female teenagers reach puberty earlier than the Chinese women.

4.4.3 Differences in attitudes towards bras

Generally speaking, there are not any distinct differences between the White-British respondents and the Chinese respondents on the attitudes towards bras, there are only differences on the extent of the agreement or the disagreement. For example, the White-British respondents have a stronger feeling of agreement than the Chinese respondents to the statements of 'A bra is an important garment for women.' and 'A bra can provide support to the breasts.' The White-British respondents have a stronger feeling of disagreement than the Chinese respondents to the statements of 'I prefer not to wear a bra.' and ' I am wearing a bra just because it is socially correct, otherwise, I'd rather not wearing a bra.'.

But there exists different opinions in the following two statements. To the statement of 'Wearing a bra is more comfortable.', most of the White-British respondents agreed with it, but the Chinese respondents selected neutral, this means the Chinese respondents are not so satisfied with the comfort property of the bra as the White-British respondents are. To the statement of 'I am happy to improve my breast shape and support by wearing a bra using harmless Non-fabric materials, such as polymer and rubber.', most of the White-British respondents selected neutral, but the Chinese respondents were disagree with it, this means the Chinese respondents have more sensitive feelings to the materials of bras.

4.4.4 Differences in preferred styles

There are not distinct differences of preferred styles between the White-British respondents and the Chinese respondents for most of the bra styles. But there is an inclination for the

Chinese respondents to like soft-padded bras and strapless bras more than the White-British respondents, and the Chinese respondents tend to dislike balcony bras more than the White-British respondents.

4.4.5 Differences in the importance of bra properties

By comparing means of bra properties between the White-British respondents and the Chinese respondents, the results were obtained as shown in Table 4.36.

Table 4.36 Differences in the importance of bra properties

	Ethnic origin								
	White - British			Chinese			Total		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Fit	1.91	180	1.357	2.04	57	1.414	1.94	237	1.369
Comfort	2.26	180	1.495	2.16	57	1.386	2.23	237	1.467
Quality	4.46	180	1.558	3.89	57	1.676	4.32	237	1.602
Material	5.61	180	1.598	4.19	57	2.167	5.27	237	1.848
Breast support	3.59	180	1.836	5.54	57	1.983	4.06	237	2.046
Price	6.57	180	1.803	6.56	57	1.803	6.57	237	1.799
Brand	8.27	180	1.389	7.21	57	2.085	8.01	237	1.643
Style	5.40	180	1.667	6.23	57	1.669	5.60	237	1.701
Color	6.94	180	1.707	7.18	57	1.465	7.00	237	1.652

By putting the importance of the properties into orders from the most important to the least important, results were obtained as below:

(1) For the White-British respondents: Fit, Comfort, Breast support, Quality, Style, Material, Price, Color, Brand

(2) For the Chinese respondents: Fit, Comfort, Quality, Material, Breast support, Style, Price, Color, Brand

For all of the respondents: Fit, Comfort, Breast support, Quality, Material, Style, Price, Color, Brand

There is no difference in the front part and the back part of the sequence, but there are some differences in the middle. The differences between the White-British respondents and the Chinese respondents are the White-British respondents pay more attention to the breast support property than the Chinese respondents, but the Chinese respondents pay more attention to the quality and material properties of the bra than the White-British respondents.

4.4.6 Differences in the satisfaction of existing bras

Figure 4.5 shows that the White-British respondents are more satisfied with the existing bras than the Chinese respondents. There is not distinct difference for the reasons why they are not satisfied. It means the existing bra products in the fashion market of China are not good enough to satisfy the consumers.

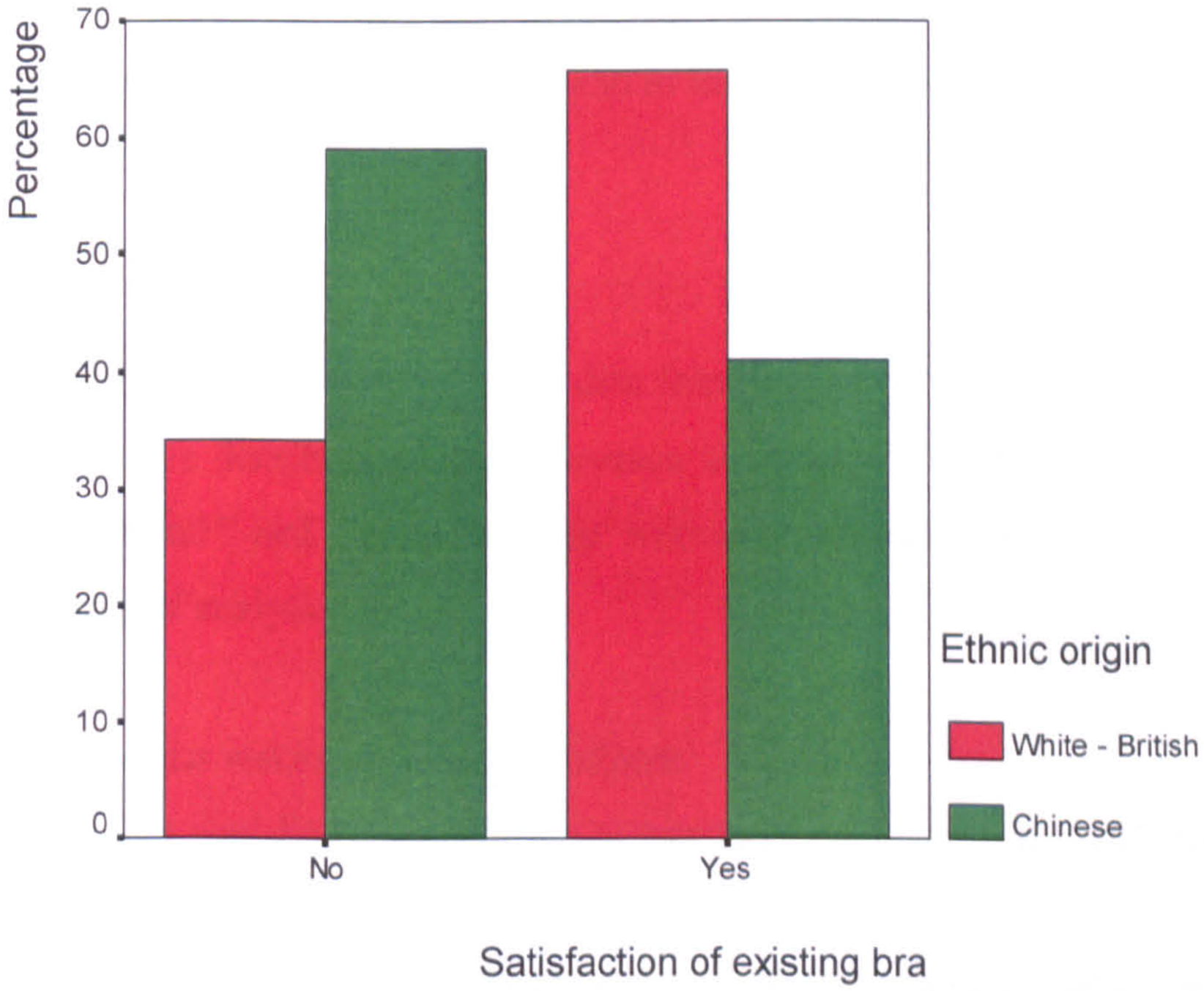


Figure 4.5 Difference in the satisfaction of existing bras

4.4.7 Difference in the hard-to-fit areas of the bra

Both the White-British respondents and the Chinese respondents agreed that they can not always find perfect fit bras, but there is some difference for the hard-to-fit areas of the bra between the White-British respondents and the Chinese respondents. More Chinese respondents reported that Area 5 (the high point of bust), and Area 7(the strap) are harder to fit than the White-British respondents, it is probably because Chinese women have an inclination towards smaller bra cup sizes, it is hard for smaller cup sized women to get a perfect fit in the high point of bust. For other areas, there is no distinct difference.

4.5 Conclusion

This chapter is mainly discussed in the analysis of some issues relating to women's bra wearing habits, attitudes and breast health problems. The findings may be used to explain the female customers' bra purchase behaviour and to improve the bra fitting and design.

4.5.1 Conclusion of basic analysis

The basic analysis reveals an overview of the data from the survey. The research questions of 'What is the bra size distribution among women nowadays?', 'What are the women's wearing habits of bras?' and 'What are the women's attitudes towards bras?' were answered by this part of analysis.

Results from this analysis were concluded as follows:

(1) The age and the bra size distribution of the respondents are accordance with the female bra consumer in the market.

(2) Most of the women wear a bra during waking hours, 14 hours a day, and began to wear a bra at an average age of 13.

(3) Most of the women own from 6 to 10 bras, buy 3 to 5 new bras a year, and a bra's average life is 9 months to 18 months.

(4) More than half of the women are wearing their day bras when doing exercise, and just about only a third of women use sports bras.

(5) About two thirds of women experience the need to wear different sizes of bras, due to small variations amongst styles and brands and the changes of body shape and weight.

(6) Less than 10% of women reported they had any medical problem with their breasts and which would influences their selection of a bra. In fact, women are not sure if wearing a bra is good for their breast health.

(7) In general, women have a positive attitude towards bras.

(8) The more favoured styles of bras for women are the underwired bra, the T-shirt bra and the balcony bra, the least favoured style is the soft bra.

(9) The functional properties of a bra, such as fit, comfort and support are more important in a woman's mind than the visual properties such as style, color and brand.

(10) More than one third of women are not satisfied with their existing bras in terms of size and comfort properties. More than two thirds of women sometimes failed to find a perfectly fitting bra; the areas most difficult to fit of a bra are the centre neck edge and the upper underarm.

4.5.2 Conclusion of correlation analysis

Correlations between the responses were analysed and discussed, the research questions of 'Are there any relationships among women's wearing habits, women's attitudes towards bra and wearer's demographic characters?' was answered.

Results from this analysis were concluded as follows:

(1) Wearers who are heavier in total weight tend to wear a bigger sized bra, especially one with a bigger back size.

(2) Women with large bra sizes tend to wear their bras for a longer time during a day and began to wear a bra at an earlier age, this last probably because larger breasts need more and earlier support.

(3) Younger women tend to own more bras than older women. Women who have more owned bras tend to buy more new bras, and tend to discard a bra more soon.

(4) Older women more often have medical problems with their breasts than younger women.

(5) Older women prefer non-padded underwired bras, but younger women prefer padded underwired bras, balcony bras and push up bras. Bigger sized women prefer non-padded bras, but smaller sized women prefer padded bras and push-up bras. Women who prefer padded underwired bras may also favour balcony, push-up, strapless and T-shirt bras. Women who prefer non-padded underwired bras seem not to choose padded or push up bras.

(6) Bigger sized women prefer full support for their breasts, whilst smaller sized women prefer medium or light support for their breasts.

(7) Older women tend to pay a lot of attention to the material and brand of the bra. Heavier and bigger cup sized women tend to think breast support is the most important.

(8) Older women think the centre underband of the bra is hard to fit, but the centre neck edge is probably easy to fit. Women who need a larger back size find the centre front is relatively easy to fit, but the centre back is quit hard to fit. Those who need a bigger cup size find the centre front and the upper underarm are difficult to fit, but the high point of the bust is quite easy to fit.

(9) The lower underarm and the upper underarm, and the wing back and the centre back are two positive pairs where either a good fit or a poor fit is achieved at the same time for both in the pair. There are four negative pairs where if one fits well, the fit of the other will be worse; these are centre front and wing back, centre underband and high point of the bust, upper underarm and high point of the bust, upper underarm and centre neck edge.

4.5.3 Conclusion of comparison analysis

Comparison analysis was carried out between the White-British respondents and the Chinese respondents, the research question of 'Are there any differences among the respondents from different ethical origins?' is answered.

Results from this analysis were concluded as follows:

(1) White-British women are a bit taller and heavier than Chinese women. Chinese women tend to have a narrower range of bra cup sizes than White-British women.

(2) White-British women wear a bra for a little longer than Chinese women during the day, and began to wear a bra about 3 years earlier than Chinese women.

(3) Chinese women are not so satisfied with the comfort of their bras and are more sensitive to the material of the bra.

(4) White-British women pay more attention to the breast support property, but Chinese women pay more attention to quality and material.

(5) White-British women are more satisfied than Chinese women with their existing bras.

(6) The high point of the bust and the strap of the bra are harder to fit for Chinese women than for White-British women.

Chapter Five
Results and discussion: sensations associated with wearing a bra

5.1 Introduction

This chapter is mainly discussed in analysis of women's sensations of pressure, discomfort and pain caused by wearing a bra. It contains the results and subsequent analysis and discussion of the responses to the questionnaire about the general sensations of pressure, discomfort and pain caused by wearing a bra. Included in the discussion, were the amount of the sensations caused by wearing a bra, the correlations of these with other factors relating to the wearers, and the classifications of the respondents.

5.2 The selection of cases and data recoding

5.2.1 The selection of cases

Four questions (Q.22, Q.23, Q.24 and Q.26) in the questionnaire are relating to the sensations associated with wearing a bra. In order to carry out the analysis effectively among the respondents, the qualified data should be the responses with no missing answer in these four questions. Based on the explanation of the questionnaires' types (see Section 3.2.4.1), the questionnaire types of A, B and C+ are satisfied with the requirements, the data from these three types of questionnaires were used to carry out the analysis.

5.2.2 Data recoding

In the original coding, the responses for the Q.22, 24 and 26 were coded as follows:

Very strong: 1

Strong: 2

Average: 3

Light: 4

Very light: 5

None: 6

As discussed before, a kind of psychophysical scale, the Borg CR10 scale which is shown in Table 5.1, was used to evaluate the sensations, the responses of the Q.22, 24 and 26 were recoded based on the Borg CR10 scale.

Table 5.1 The Borg CR10 Scale

0	Nothing at all	'No P'
0.3		
0.5	Extremely weak	Just noticeable
1	Very weak	
1.5		
2	Weak	Light
2.5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	Extremely strong	'Max P'
11		
~		
•	Absolute maximum	Highest possible

Borg CR10 scale
©Gunnar Borg, 1981,1982,1998

Therefore the recoded data are shown as follows:

Very strong: 7

Strong: 5

Average: 3

Light: 2

Very light: 1

None: 0

5.3 Basic analysis of means and frequencies

5.3.1 Pressure sensations due to wearing a bra

The question is:

Q.22. When you are wearing a bra, reference to daily wear bras, can you select an option that best describes the amount of PRESSURE or TIGHTNESS you feel in different areas of the bra (The areas showed in Figure 5.1)?

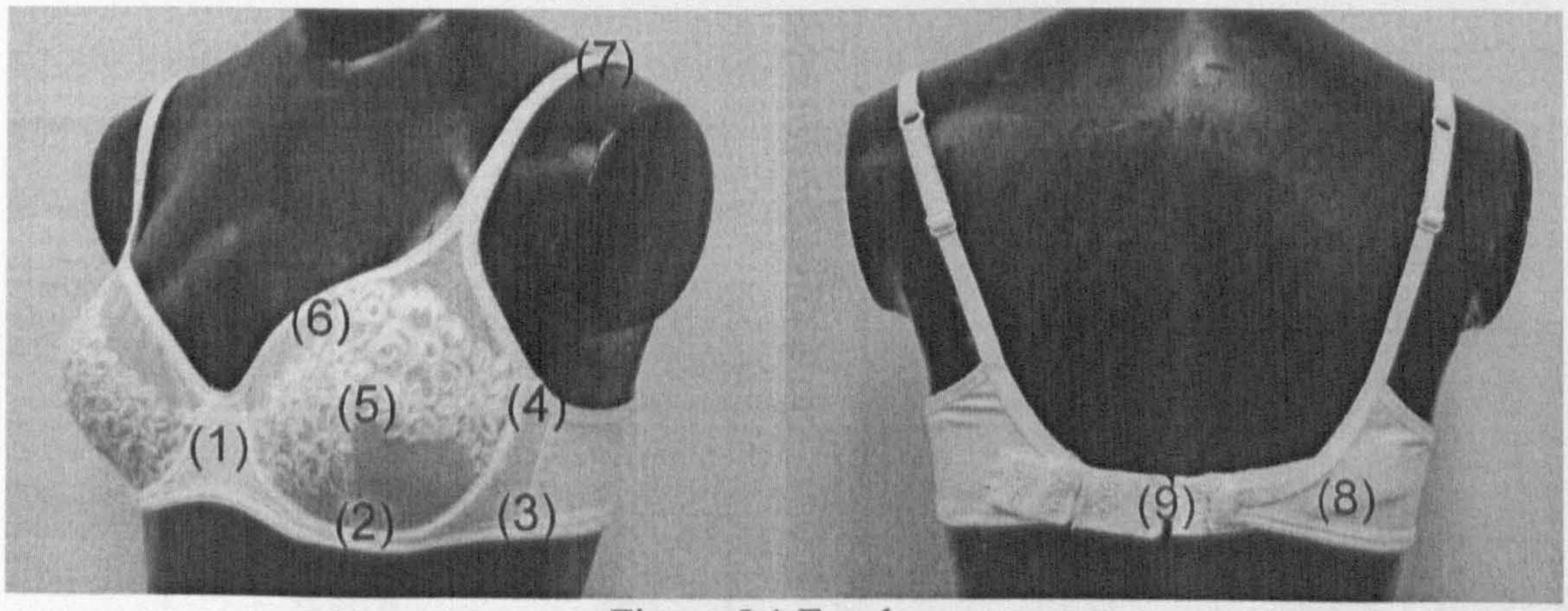


Figure 5.1 Focal areas

	Very strong	Strong	Average	Light	Very light	None
The PRESSURE in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

Table 5.2 shows the statistical results of the descriptive analysis. From the means, it was discovered that the strongest sensation of pressure is experienced in Area 2; the weakest sensation of pressure is experienced in Area 6. The value of pressure sensations for Areas 2, 4 and 7 are moderate, the value of pressure sensations for Areas 1, 3, 8 and 9 are about weak to moderate, and the value of pressure sensations for Areas 5 and 6 are about very weak to weak. The skewness reflects the asymmetry of a distribution. In this survey, the data with a big positive skewness means that more respondents tend to select weaker sensations than the mean, and the data with a big negative skewness means more respondents tend to select stronger sensations than the mean. Therefore, for Area 5, a big positive skewness of 0.670 means more respondents tend to feel weaker sensations of pressure than the mean, and the same situation occurs for Areas 1 and 6.

Table 5.2 Descriptive statistics of pressure sensations

Pressure sensation	N	Mean	Std. Deviation	Skewness
Area 1	263	2.67	1.835	0.300
Area 2	263	3.45	1.819	-0.145
Area 3	263	2.98	1.716	-0.092
Area 4	263	3.13	1.714	0.091
Area 5	263	1.76	1.455	0.670
Area 6	263	1.70	1.421	0.390
Area 7	263	3.20	1.847	0.084
Area 8	263	2.71	1.669	0.067
Area 9	263	2.59	1.682	0.242

5.3.2 Discomfort sensations due to wearing a bra

The questions are:

Q.23. Some women experience discomfort when wearing bra. Do you think the discomfort of bra is totally caused by pressure? That means do you think the pressure sensations and the discomfort sensations caused by wearing a bra are the same? If Yes, Skip to Q.25. If No, Go to Q.24.

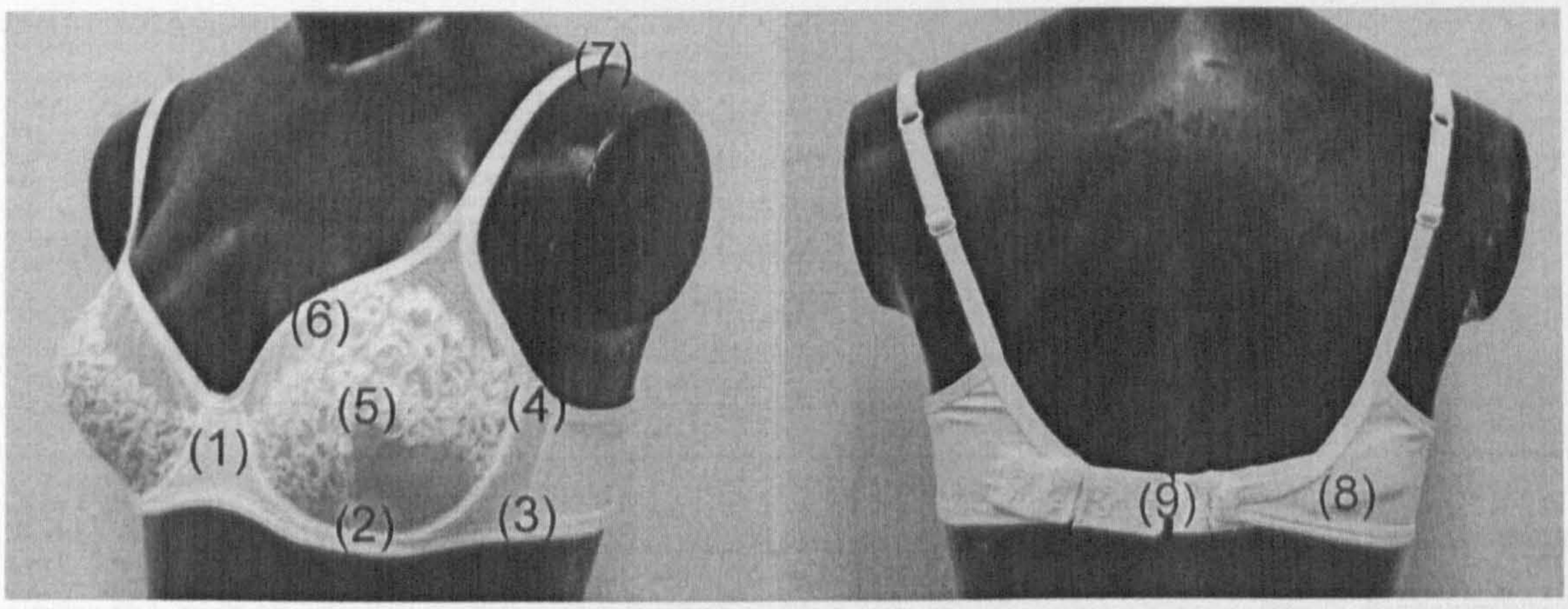


Figure 5.2 Focal areas

	Very strong	Strong	average	light	Very light	none
The DISCOMFORT in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

Q.24. Can you select an option that best describes the amount of DISCOMFORT you feel in different areas of the bra (The areas showed in Figure 5.2).
Q.25. Do you think which of the following factors can influence the discomfort sensation of the bra?

Table 5.3 shows two thirds of the respondents reported that the discomfort sensation is totally caused by the pressure generated from a bra. Those who do not think the discomfort sensation is the same with the pressure sensation answered the question on how much discomfort they feel in different areas of the bra.

Table 5.3 Do you agree discomfort is totally caused by pressure

Discomfort is totally caused by pressure		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	No	88	33.5	33.5	33.5
	Yes	175	66.5	66.5	100.0
	Total	263	100.0	100.0	

Table 5.4 shows the statistical results of the descriptive analysis of discomfort sensations. From the means, it was discovered that the strongest sensation of discomfort is experienced in Area 7; the weakest sensation of discomfort is experienced in Area 5. The value of discomfort sensations for Areas 2 and 7 are moderate, the value of discomfort sensations for Areas 1, 3 and 4 are about weak to moderate, and the value of discomfort sensations for Areas 5, 6, 8 and 9 are about very weak to weak. For Areas 1, 5, 6, 8, and 9, the big positive skewnesses mean that more respondents tend to select weaker sensations than the mean.

Table 5.5 contains the factors which influence the discomfort sensations of wearing a bra. The most selected factor is the underwire, occupies 36.0% of the responses. The fabric and the seam are also the important factors which can influence the discomfort sensations. Some of the respondents also reported other factors which influence the discomfort

sensations, such as the incorrect bra size, the style, the elastic of material, air and water permeability, the strap, and the lace and the labels.

Table 5.4 Descriptive statistics of discomfort sensations

Discomfort sensation	N	Mean	Std. Deviation	Skewness
Area 1	89	2.52	2.232	0.599
Area 2	89	3.07	2.184	0.166
Area 3	89	2.29	1.890	0.331
Area 4	89	2.75	1.897	0.130
Area 5	89	1.25	1.325	0.609
Area 6	89	1.48	1.531	0.655
Area 7	89	3.13	2.085	-0.122
Area 8	89	1.81	1.671	0.654
Area 9	89	1.99	1.856	0.846

Table 5.5 Factors which influence the discomfort sensations of wearing a bra

Factors which influencing the discomfort sensations of a bra	Numbers of responses	Percentage of responses
Don't know	15	2.5
The fabric	158	26.6
The seam	121	20.3
The wire	214	36.0
The padding material	51	8.6
Other	36	6.1
Total	595	100.0

5.3.3 Pain sensation due to wearing a bra

The question is:

Q.26. Do you experience any PAIN when you are wearing a bra during your daily life? If Yes, can you select an option that best describes the level of pain in the following areas of the bra (The areas showed in Figure 5.3)?

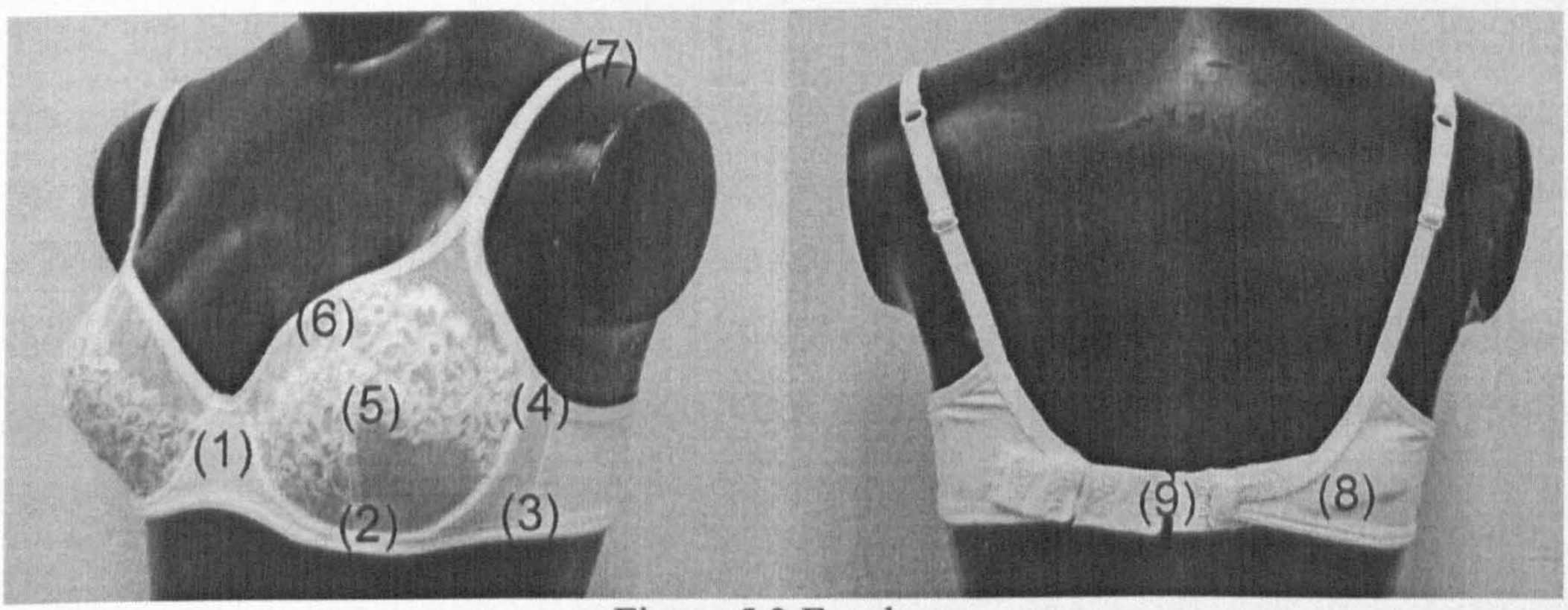


Figure 5.3 Focal areas

	Very severe	Severe	average	light	Very light	none
The PAIN occurs in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

Table 5.6 shows that there are 28.5% of the respondents experience pain when wearing a bra.

Table 5.6 Experience pain when wearing a bra

Experience pain when wearing a bra		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	No	188	71.5	71.5	71.5
	Yes	75	28.5	28.5	100.0
	Total	263	100.0	100.0	

Table 5.7 shows the statistical results of the descriptive analysis of pain sensations. From the means, it was discovered that the strongest sensation of pain is experienced in Area 4; the weakest sensation of pain is experienced in Area 5. The value of pain sensation for Area 4 is moderate, the value of pain sensations for Areas 2 and 7 are about weak to moderate, the value of pain sensations for Areas 1, 3, 8 and 9 are about very weak to weak, and there are almost no pain sensations for Areas 5 and 6. For Areas 5, 6, 8, and 9, the big positive skewnesses mean more respondents tend to feel weaker sensations than the mean.

Table 5.7 Descriptive statistics of pain sensation

Pain sensation	N	Mean	Std. Deviation	Skewness
Area 1	76	1.71	1.965	0.796
Area 2	76	2.11	1.929	0.453
Area 3	76	1.76	1.999	0.788
Area 4	76	2.91	2.124	0.167
Area 5	76	0.54	1.038	1.616
Area 6	76	0.64	1.067	1.301
Area 7	76	2.16	2.148	0.494
Area 8	76	1.13	1.739	1.669
Area 9	76	0.93	1.436	1.478

5.4 Correlations with other responses

5.4.1 Correlations between pressure sensations and other responses

5.4.1.1 Correlations between pressure sensations and the bra size

Using correlation analysis, results were obtained as shown in Table 5.8. The column, titled Explanation, in the far right side of the table explains the meaning of the data in every row, in order to save spaces, this column will not appear in the following similar tables from Table 5.9 until Table 5.17.

Table 5.8 Correlations between pressure sensations and bra size

Correlations between pressure sensation and bra size			
Bra size / Pressure sensation	Bra back size	Bra cup size	Explanation
Area 1	-0.138(*) 0.025 262	-0.107 0.084 261	Correlation Coefficient Significance N
Area 2	-0.011 0.855 262	-0.005 0.939 261	Correlation Coefficient Significance N
Area 3	0.009 0.883 262	0.044 0.482 261	Correlation Coefficient Significance N
Area 4	-0.029 .645 262	-0.021 .737 261	Correlation Coefficient Significance N
Area 5	0.055 0.379 262	0.048 0.437 261	Correlation Coefficient Significance N
Area 6	-0.011 0.862 262	0.062 0.318 261	Correlation Coefficient Significance N
Area 7	0.093 0.135 262	0.129(*) 0.037 261	Correlation Coefficient Significance N
Area 8	0.039 0.527 262	0.151(*) 0.015 261	Correlation Coefficient Significance N
Area 9	0.107 0.083 262	0.067 0.280 261	Correlation Coefficient Significance N

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 5.8 shows that there is a negative significant correlation between the bra back size and the pressure sensation in Area 1, which means, for women with bigger bra back size, the pressure sensation experienced in the centre front area of the bra is lighter. However, there are positive significant correlations between the bra cup size and pressure sensations in Areas 7 and 8, this means the pressure sensations experiences by women with bigger bra

cup size in these two areas are stronger; this is probably because the shoulder and the back areas bear the most of the weight from the big breasts.

5.4.1.2 Correlations between pressure sensations and the hard-to-fit areas of a bra

Table 5.9 shows correlations between pressure sensations and hard-to-fit areas. There are positive significant correlations between pressure sensation in Area 3 and the hard-to-fit Area 3, pressure sensation in Area 4 and hard-to-fit Area 4, which means if the pressure sensations are stronger in these two areas, these two areas tend to be harder to fit. The same situations occur between pressure sensation in Area 3 and the hard-to-fit Area 7, and pressure sensation in Area 8 and the hard-to-fit Area 9. There are negative significant correlations between the pressure sensations in Areas 4 and 5 and the hard-to-fit Area 6, pressure sensation in Area 7 and hard-to-fit Area 5, which means if the pressure sensation in Area 7 is weaker, the Area 5 tends to be harder to fit.

5.4.1.3 Correlations among pressure sensations in different areas of a bra

Table 5.10 shows that all the correlations of pressure sensations between different areas of the bra are positive significant correlations. This means the pressure sensations have the same tendency on all the different areas of the bra; a stronger pressure sensation in one area tends to trigger a stronger pressure sensation in other areas.

Table 5.9 Correlations between pressure sensations and hard-to-fit areas

Correlations between pressure sensations and hard-to-fit areas									
Unfit areas / Pressure sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	0.077 0.285 197	0.062 0.386 197	-0.078 0.274 197	-0.064 0.370 197	0.076 0.286 197	-0.035 0.629 197	0.014 0.849 197	-0.067 0.350 197	0.044 0.542 197
Area 2	0.026 0.721 197	0.124 0.083 197	0.014 0.847 197	-0.092 0.200 197	-0.036 0.613 197	0.076 0.289 197	0.064 0.370 197	-0.109 0.128 197	-0.018 0.801 197
Area 3	0.006 0.934 197	0.128 0.072 197	0.261 (**) 0.000 197	-0.012 0.863 197	0.043 .544 197	-0.056 0.431 197	0.149 (*) 0.036 197	-0.031 0.661 197	-0.004 0.957 197
Area 4	0.031 0.663 197	-0.068 0.339 197	0.132 0.064 197	0.201 (**) 0.005 197	0.011 .879 197	-0.217 (**) 0.002 197	0.028 0.696 197	0.060 0.406 197	0.039 0.585 197
Area 5	-0.010 0.892 197	0.060 0.400 197	-0.069 0.334 197	-0.022 0.759 197	-0.057 .430 197	-0.223 (**) .002 197	0.067 0.348 197	0.064 0.375 197	0.043 0.548 197
Area 6	-0.020 0.779 197	0.128 0.073 197	-0.069 0.338 197	-0.068 0.342 197	-0.093 0.195 197	-0.122 0.087 197	0.139 0.052 197	0.063 0.380 197	0.016 0.827 197
Area 7	0.013 0.860 197	0.131 0.067 197	-0.034 0.637 197	-0.003 0.970 197	-0.144 (*) 0.043 197	-0.077 0.281 197	0.110 0.122 197	0.035 0.626 197	0.089 0.214 197
Area 8	0.058 0.415 197	0.009 0.895 197	0.012 0.870 197	-0.055 0.442 197	-0.011 .883 197	-0.121 0.092 197	0.105 0.142 197	0.139 0.052 197	0.181(*) 0.011 197
Area 9	-0.007 0.920 197	0.012 0.871 197	-0.059 0.409 197	-0.105 0.144 197	0.033 0.644 197	-0.118 0.099 197	0.021 0.771 197	0.107 0.133 197	0.135 0.059 197

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 5.10 Correlations among pressure sensations in different areas

Correlations within the pressure sensations in different areas									
Pressure sensation / Pressure sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	1.000 . 263								
Area 2	0.459 (**) 0.000 263	1.000 . 263							
Area 3	0.310 (**) 0.000 263	0.459 (**) 0.000 263	1.000 . 263						
Area 4	0.245 (**) 0.000 263	0.292 (**) 0.000 263	0.500 (**) 0.000 263	1.000 . 263					
Area 5	0.295 (**) 0.000 263	0.269 (**) 0.000 263	0.364 (**) 0.000 263	0.357 (**) 0.000 263	1.000 . 263				
Area 6	0.271 (**) 0.000 263	0.244 (**) 0.000 263	0.358 (**) 0.000 263	0.210 (**) 0.001 263	0.649 (**) 0.000 263	1.000 . 263			
Area 7	0.169 (**) 0.006 263	0.292 (**) 0.000 263	0.388 (**) 0.000 263	0.259 (**) 0.000 263	0.358 (**) 0.000 263	0.327 (**) .000 263	1.000 . 263		
Area 8	0.249 (**) 0.000 263	0.252 (**) 0.000 263	0.484 (**) 0.000 263	0.245 (**) .000 263	0.434 (**) 0.000 263	0.504 (**) 0.000 263	0.489 (**) 0.000 263	1.000 . 263	
Area 9	0.213 (**) 0.001 263	0.228 (**) 0.000 263	0.406 (**) 0.000 263	0.226 (**) .000 263	0.470 (**) 0.000 263	0.482 (**) 0.000 263	0.435 (**) 0.000 263	0.686 (**) 0.000 263	1.000 . 263

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

5.4.2 Correlations between discomfort sensations and other responses

5.4.2.1 Correlations between discomfort sensations and the hard-to-fit areas of a bra

Table 5.11 shows correlations between discomfort sensations and the hard-to-fit areas. There are positive significant correlations between discomfort sensations in Area 4 and the hard-to-fit Area 4, discomfort sensation in Area 7 and the hard-to-fit Area 7, and discomfort sensation in Area 9 and the hard-to-fit Area 9, which means if the discomfort sensations are stronger in Areas 4, 7 and 9, these areas tend to be harder to fit. There is one negative significant correlation between discomfort sensation in Area 5 and the hard-to-fit Area 2, this means if the discomfort sensation in Area 5 is tend to be smaller, the Area 2 tend to be more hard to fit.

5.4.2.2 Correlations among discomfort sensations in different areas of a bra

From Table 5.12, it was discovered that almost all correlations among the discomfort sensations in different areas are positive significant correlations, which means the discomfort sensations have the same tendency for all the different areas of a bra; a stronger discomfort sensation in one area means there are stronger discomfort sensations in other areas. But there is an exception; there is no distinct correlation between the discomfort sensation in Area 4 and the discomfort sensation in Area 1, this means a stronger discomfort sensation in Area 4 can not trigger a stronger discomfort sensation in Area 1.

Table 5.11 Correlations between discomfort sensations and the hard-to-fit areas of a bra

Correlations between discomfort sensations and the hard-to-fit areas of a bra									
Unfit areas / Discomfort sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	0.088 0.474 69	0.108 0.377 69	-0.164 0.178 69	-0.129 0.291 69	0.107 0.381 69	0.144 0.236 69	-0.041 0.739 69	0.016 0.896 69	0.114 0.352 69
Area 2	0.135 0.269 69	0.145 0.235 69	0.130 0.289 69	-0.059 0.628 69	-0.050 0.685 69	0.164 0.179 69	0.136 0.267 69	-0.093 0.448 69	-0.105 0.389 69
Area 3	0.060 0.623 69	0.116 0.344 69	0.141 0.249 69	0.160 0.189 69	0.085 0.487 69	0.008 0.951 69	-0.130 0.286 69	0.070 0.567 69	-0.013 0.913 69
Area 4	0.034 0.782 69	-0.092 0.454 69	0.050 .684 69	0.343 (**) 0.004 69	-0.109 0.373 69	-0.123 0.316 69	-0.185 0.127 69	0.157 0.198 69	-0.121 0.323 69
Area 5	0.014 0.909 69	-0.250 (*) 0.038 69	0.033 0.785 69	-0.092 0.450 69	0.000 1.000 69	0.035 0.778 69	-0.085 0.488 69	-0.013 0.916 69	-0.026 0.835 69
Area 6	0.037 0.761 69	-0.162 0.183 69	-0.021 0.861 69	-0.151 0.215 69	-0.101 0.408 69	0.218 0.072 69	-0.026 0.832 69	-0.010 0.933 69	-0.033 0.786 69
Area 7	0.103 0.401 69	0.179 0.141 69	0.032 0.793 69	-0.017 0.891 69	-0.207 0.088 69	0.134 0.273 69	0.316 (**) 0.008 69	-0.173 0.154 69	-0.077 0.529 69
Area 8	0.183 0.132 69	-0.060 0.621 69	0.024 0.843 69	-0.072 0.555 69	0.023 0.853 69	0.083 0.499 69	0.044 0.720 69	0.065 0.595 69	-0.062 0.615 69
Area 9	-0.058 0.633 69	0.001 0.994 69	-0.034 0.783 69	0.060 0.626 69	0.211 0.082 69	0.079 0.516 69	-0.095 .436 69	0.086 0.482 69	0.325 (**) .006 69

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5.12 Correlations among discomfort sensations in different areas

Correlations within the discomfort sensations in different areas									
Discomfort sensation / Discomfort sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	1.000 . 89								
Area 2	0.327 (**) 0.002 89	1.000 . 89							
Area 3	0.252 (*) 0.017 89	0.564 (**) 0.000 89	1.000 . 89						
Area 4	0.198 0.063 89	0.237 (*) 0.026 89	0.596 (**) 0.000 89	1.000 . 89					
Area 5	0.368 (**) 0.000 89	0.456 (**) 0.000 89	0.419 (**) 0.000 89	0.240 (*) 0.024 89	1.000 . 89				
Area 6	0.397 (**) 0.000 89	0.419 (**) 0.000 89	0.409 (**) 0.000 89	0.321 (**) 0.002 89	0.751 (**) 0.000 89	1.000 . 89			
Area 7	0.222 (*) .037 89	0.487 (**) 0.000 89	0.267 (*) 0.011 89	0.232 (*) 0.028 89	0.256 (*) 0.015 89	0.319 (**) 0.002 89	1.000 . 89		
Area 8	0.322 (**) .002 89	0.488 (**) .000 89	0.422 (**) 0.000 89	0.224 (*) .035 89	0.639 (**) 0.000 89	0.686 (**) 0.000 89	0.405 (**) 0.000 89	1.000 . 89	
Area 9	0.538 (**) .000 89	0.306 (**) 0.004 89	0.459 (**) 0.000 89	0.323 (**) 0.002 89	0.565 (**) .000 89	0.592 (**) 0.000 89	0.270 (*) 0.011 89	0.650 (**) 0.000 89	1.000 . 89

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5.13 Correlations between discomfort sensations and pressure sensations

Correlations between discomfort sensations and pressure sensations									
Pressure sensation / Discomfort sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	0.492 (**) 0.000 89	0.102 0.341 89	0.149 0.164 89	0.171 0.110 89	0.155 0.147 89	0.086 0.423 89	0.131 0.221 89	0.113 0.291 89	0.142 0.185 89
Area 2	0.192 0.071 89	0.520 (**) 0.000 89	0.275 (**) 0.009 89	0.079 0.464 89	0.206 0.053 89	0.110 0.305 89	0.122 0.255 89	0.178 0.096 89	0.268 (*) 0.011 89
Area 3	0.091 0.397 89	0.263 (*) 0.013 89	0.257 (*) 0.015 89	0.226 (*) 0.034 89	0.318 (**) 0.002 89	0.037 0.732 89	0.130 0.224 89	0.104 0.333 89	0.285 (**) 0.007 89
Area 4	0.219 (*) 0.040 89	0.275 (**) 0.009 89	0.185 0.083 89	0.457 (**) 0.000 89	0.384 (**) 0.000 89	0.068 0.528 89	0.302 (**) 0.004 89	0.060 0.575 89	0.155 0.148 89
Area 5	0.249 (*) 0.018 89	0.124 0.247 89	0.177 0.097 89	0.003 0.974 89	0.400 (**) 0.000 89	0.262 (*) 0.013 89	0.091 0.395 89	0.260 (*) 0.014 89	0.337 (**) 0.001 89
Area 6	0.197 0.064 89	0.040 0.709 89	0.107 0.318 89	-0.002 0.982 89	0.293 (**) 0.005 89	0.234 (*) 0.027 89	0.134 0.210 89	0.189 0.076 89	0.189 0.076 89
Area 7	0.084 0.436 89	0.272 (**) 0.010 89	0.148 0.165 89	0.065 0.542 89	-0.014 0.895 89	0.002 0.984 89	0.313 (**) 0.003 89	0.108 0.316 89	0.014 0.896 89
Area 8	0.222 (*) 0.036 89	0.144 0.178 89	0.187 0.079 89	-0.107 0.317 89	0.277 (**) 0.009 89	0.225 (*) 0.034 89	0.303 (**) 0.004 89	0.466 (**) 0.000 89	0.393 (**) 0.000 89
Area 9	0.258 (*) 0.015 89	0.067 0.531 89	0.150 0.161 89	0.070 0.513 89	0.223 (*) 0.035 89	0.061 0.571 89	0.170 0.112 89	0.143 0.181 89	0.284 (**) 0.007 89

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

5.4.2.3 Correlations between discomfort sensations and pressure sensations in different areas of a bra

From Table 5.13, it was discovered that there are significant positive correlations between discomfort sensations and pressure sensations in some of the areas. There are two kinds of positive correlations. One kind is, for all the areas, a stronger pressure sensation can trigger a stronger discomfort sensation in the same area. The other kind is a stronger pressure sensation in one area can trigger a stronger discomfort sensation in other areas, these areas are shown below:

(1) Pressure sensation in Area 1 and discomfort sensation in Areas 4, 5, 8 and 9

(2) Pressure sensation in Area 2 and discomfort sensation in Areas 3, 4 and 7

(3) Pressure sensation in Area 3 and discomfort sensation in Area 2

(4) Pressure sensation in Area 4 and discomfort sensation in Area 3

(5) Pressure sensation in Area 5 and discomfort sensation in Areas 3, 4, 6, 8, and 9

(6) Pressure sensation in Area 6 and discomfort sensation in Areas 5 and 8

(7) Pressure sensation in Area 7 and discomfort sensation in Areas 4 and 8

(8) Pressure sensation in Area 8 and discomfort sensation in Area 5

(9) Pressure sensation in Area 9 and discomfort sensation in Areas 2, 3, 5 and 8

5.4.3 Correlations between pain sensations and other responses

5.4.3.1 Correlations between pain sensations and the hard-to-fit areas of a bra

Table 5.14 shows correlations between pain sensations and the hard-to-fit areas. There are positive significant correlations between pain sensation in Area 1 and the hard-to-fit Area 1, pain sensation in Area 3 and the hard-to-fit Area 3, pain sensation in Area 4 and the hard-to-fit Area 4, pain sensation in Area 7 and the hard-to-fit Area 7, which means if the pain sensations are stronger in Areas 1, 3, 4 and 7, these areas tend to be more hard to fit. Besides, there are positive significant correlations between pain sensations in Areas 2, and

5 and the hard-to-fit Area 7, this means if the pain sensations in Areas 2 or 5 are tend to be smaller, the Area 7 tend to be more hard to fit.

Table 5.14 Correlations between pain sensations and the hard-to-fit areas

Correlations between pain sensations and the hard-to-fit areas									
Pain sensation \ Unfit areas	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	0.302 (*) 0.013 67	-0.009 0.945 67	-0.004 0.976 67	-0.028 0.824 67	-0.018 0.885 67	0.011 0.930 67	0.041 0.744 67	-0.093 0.454 67	0.068 0.582 67
Area 2	0.005 0.967 67	0.216 0.079 67	0.092 0.461 67	-0.018 0.886 67	-0.007 0.953 67	0.146 0.240 67	0.250 (*) 0.041 67	-0.095 0.444 67	-0.007 0.958 67
Area 3	0.034 0.783 67	-0.083 0.502 67	0.379 (**) 0.002 67	0.059 0.638 67	0.124 0.319 67	0.006 0.963 67	0.231 .060 67	0.198 0.108 67	-0.028 0.820 67
Area 4	0.003 0.984 67	0.021 0.866 67	0.129 0.299 67	0.397 (**) 0.001 67	-0.186 0.131 67	-0.035 0.776 67	0.010 .934 67	-0.053 0.671 67	0.012 0.925 67
Area 5	-0.083 0.502 67	-0.112 0.368 67	0.006 0.960 67	-0.076 0.539 67	0.010 0.939 67	-0.071 0.570 67	0.260 (*) .033 67	0.031 0.803 67	-0.073 0.559 67
Area 6	0.096 0.438 67	-0.151 0.222 67	0.108 0.382 67	-0.094 0.447 67	0.071 0.566 67	-0.005 0.969 67	0.090 0.468 67	-0.011 0.933 67	0.019 0.878 67
Area 7	0.047 0.708 67	0.070 0.573 67	0.011 0.932 67	0.081 0.514 67	-0.079 0.527 67	0.053 0.669 67	0.270 (*) 0.027 67	-0.017 0.888 67	-0.048 0.702 67
Area 8	0.173 0.162 67	-0.096 0.440 67	0.147 0.235 67	-0.026 0.833 67	-0.059 0.635 67	-0.054 0.666 67	0.213 0.083 67	0.087 0.482 67	0.170 0.170 67
Area 9	0.013 0.915 67	-0.059 0.636 67	0.060 0.629 67	-0.036 0.774 67	-0.003 0.981 67	0.046 0.712 67	0.199 0.107 67	0.088 0.479 67	0.224 0.068 67

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

5.4.3.2 Correlations among the pain sensations in different areas of a bra

From Table 5.15, it was discovered that almost all correlations among the pain sensations in different areas are positive significant correlations, which means the pain sensations have the same tendency for all the different areas of a bra; a stronger pain sensation in one area tend to trigger a stronger pain sensation in other areas. But there are some exceptions, the detailed information is shown in Table 5.15.

5.4.3.3 Correlations between pain sensations and pressure sensations in different areas of a bra

From Table 5.16, it was discovered that there are significant positive correlations between pain sensations and pressure sensations in some of the areas. As explained before, there are two kinds of positive correlations. One is, for all the areas except Area 6, a stronger pressure sensation can trigger a stronger pain sensation in the same area. The other is a stronger pressure sensation in one area can trigger a stronger pain sensation in another areas. These areas are shown below:

(1) Pressure sensation in Area 8 and pain sensation in Area 6

(2) Pressure sensation in Area 9 and pain sensation in Areas 5 and 8

5.4.3.4 Correlations between pain sensations and discomfort sensations in different areas of a bra

From Table 5.17, it was discovered that there are significant positive correlations between pain sensations and discomfort sensations in some of the areas.

Table 5.15 Correlations among pain sensations in different areas

Correlations among pain sensations in different areas									
Pain sensation / Pain sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	1.000 . 76								
Area 2	0.341 (**) 0.003 76	1.000 . 76							
Area 3	0.189 0.102 76	0.420 (**) 0.000 76	1.000 . 76						
Area 4	-0.049 0.672 76	0.181 0.117 76	0.377 (**) 0.001 76	1.000 . 76					
Area 5	0.358 (**) 0.002 76	0.381 (**) 0.001 76	0.413 (**) 0.000 76	0.206 0.074 76	1.000 . 76				
Area 6	0.397 (**) 0.000 76	0.350 (**) 0.002 76	0.409 (**) 0.000 76	0.250 (*) 0.029 76	0.778 (**) 0.000 76	1.000 . 76			
Area 7	0.217 0.059 76	0.395 (**) 0.000 76	0.319 (**) 0.005 76	0.301 (**) 0.008 76	0.349 (**) 0.002 76	0.450 (**) 0.000 76	1.000 . 76		
Area 8	0.323 (**) 0.004 76	0.393 (**) 0.000 76	0.491 (**) 0.000 76	0.218 0.058 76	0.635 (**) 0.000 76	0.645 (**) 0.000 76	0.493 (**) 0.000 76	1.000 . 76	
Area 9	0.435 (**) 0.000 76	0.553 (**) 0.000 76	0.524 (**) 0.000 76	0.286 (*) 0.012 76	0.662 (**) 0.000 76	0.710 (**) 0.000 76	0.548 (**) 0.000 76	0.787 (**) 0.000 76	1.000 . 76

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5.16 Correlations between pain sensations and pressure sensations

Correlations between pain sensations and pressure sensations									
Pressure sensation / Pain sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	0.529 (**) 0.000 76	0.146 0.207 76	-0.060 0.608 76	-0.023 0.844 76	0.044 0.706 76	-0.075 0.519 76	-0.007 0.954 76	0.142 0.222 76	0.031 0.787 76
Area 2	0.216 0.061 76	0.260 (*) 0.023 76	0.091 0.435 76	0.042 0.719 76	-0.149 0.200 76	-0.115 0.322 76	0.010 0.933 76	-0.052 0.657 76	-0.001 0.990 76
Area 3	-0.098 0.401 76	-0.100 0.391 76	0.309 (**) 0.007 76	0.212 0.065 76	0.018 0.876 76	-0.094 0.419 76	0.054 0.643 76	0.059 0.611 76	0.028 0.809 76
Area 4	-0.142 0.221 76	-0.168 0.147 76	0.111 0.338 76	0.293 (*) 0.010 76	0.096 0.411 76	-0.034 0.769 76	0.149 0.200 76	0.111 0.341 76	0.108 0.352 76
Area 5	0.060 0.610 76	0.029 0.806 76	0.119 0.307 76	0.152 0.189 76	0.262 (*) 0.022 76	0.116 0.317 76	0.066 0.573 76	0.172 0.137 76	0.266 (*) 0.020 76
Area 6	0.105 0.367 76	-0.047 0.687 76	-0.057 0.627 76	0.016 0.889 76	0.158 0.173 76	0.164 0.158 76	-0.067 0.563 76	0.243 (*) 0.035 76	0.220 0.056 76
Area 7	0.151 0.193 76	0.034 0.774 76	0.044 0.704 76	0.168 0.147 76	0.114 0.326 76	0.044 0.704 76	0.458 (**) 0.000 76	0.171 0.141 76	0.052 0.658 76
Area 8	0.000 1.000 76	-0.056 0.632 76	0.146 0.207 76	0.086 0.462 76	0.160 0.168 76	0.090 0.439 76	0.052 0.656 76	0.309 (**) 0.007 76	0.285 (*) 0.012 76
Area 9	0.047 0.688 76	-0.026 0.821 76	-0.009 0.936 76	0.034 0.768 76	0.087 0.456 76	0.032 0.781 76	0.079 0.497 76	0.194 0.094 76	0.294 (**) 0.010 76

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5.17 Correlations between pain sensations and discomfort sensations

Correlations between pain sensations and discomfort sensations									
Discomfort sensation / Pain sensation	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Area 1	0.522 (**) 0.004 29	-0.134 0.487 29	-0.092 0.637 29	-0.128 0.508 29	0.190 0.324 29	0.118 0.540 29	0.029 0.883 29	0.244 0.203 29	0.364 0.052 29
Area 2	0.193 0.317 29	0.325 0.085 29	0.270 0.156 29	-0.076 0.696 29	0.290 0.127 29	0.327 0.084 29	0.438 (*) 0.017 29	0.411 (*) 0.027 29	0.237 0.215 29
Area 3	-0.183 0.341 29	0.107 0.580 29	0.553 (**) 0.002 29	-0.092 0.635 29	0.208 0.279 29	0.225 0.242 29	0.157 0.416 29	0.265 0.166 29	0.080 0.679 29
Area 4	-0.139 0.471 29	-0.020 0.919 29	0.334 0.077 29	0.573 (**) 0.001 29	-0.158 0.413 29	0.091 0.639 29	-0.307 0.105 29	-0.046 0.814 29	-0.120 0.534 29
Area 5	0.184 0.338 29	-0.131 0.497 29	0.088 0.651 29	-0.130 0.503 29	0.565 (**) 0.001 29	0.509 (**) 0.005 29	-0.046 0.814 29	0.444 (*) 0.016 29	0.357 0.057 29
Area 6	0.094 0.629 29	-0.199 0.301 29	-0.032 0.867 29	-0.058 0.766 29	0.361 0.054 29	0.352 0.062 29	-0.048 0.806 29	0.381 (*) 0.041 29	0.240 0.209 29
Area 7	0.300 0.114 29	-0.067 0.731 29	0.116 0.551 29	0.236 0.218 29	0.385 (*) 0.039 29	0.514 (**) 0.004 29	0.327 0.083 29	0.440 (*) 0.017 29	0.475 (**) 0.009 29
Area 8	0.143 0.460 29	0.171 0.374 29	0.433 (*) 0.019 29	0.048 0.804 29	0.620 (**) 0.000 29	0.599 (**) 0.001 29	0.137 0.478 29	0.755 (**) 0.000 29	0.486 (**) 0.007 29
Area 9	0.189 0.325 29	0.151 0.434 29	0.349 0.064 29	-0.075 0.700 29	0.497 (**) 0.006 29	0.583 (**) 0.001 29	0.219 0.254 29	0.632 (**) 0.000 29	0.494 (**) 0.006 29

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

As described before, there are two kinds of positive correlations. One is, for all the areas except Areas 2, 6 and 7, a stronger pressure sensation can trigger a stronger pain sensation in the same area. The other is a stronger pressure sensation in one area can trigger a stronger pain sensation in the other area. These areas are shown below:

(1) Discomfort sensation in Area 3 and pain sensation in Area 8

(2) Discomfort sensation in Area 5 and pain sensation in Areas 7, 8 and 9

(3) Discomfort sensation in Area 6 and pain sensation in Areas 5, 7, 8 and 9

(4) Discomfort sensation in Area 7 and pain sensation in Area 2

(5) Discomfort sensation in Area 8 and pain sensation in Areas 2, 5, 6, 7 and 9

(6) Discomfort sensation in Area 9 and pain sensation in Areas 7 and 8

5.5 The comparison between White-British respondents and Chinese respondents

As analysed in Chapter 4, a comparison between the White-British respondents and Chinese respondents about bra's wearing habits was carried out. In this Chapter, it is necessary to compare the differences between these two groups of respondents for their sensations of pressure, discomfort and pain by comparing means and chi-squares of the sensations.

It was found that there is not much differences between the White-British respondents and Chinese respondents for pressure sensations in different areas of the bra.

It was discovered that there are some differences between the White-British respondents and Chinese respondents for discomfort sensations in Area 7. The Chinese respondents tend to report stronger discomfort sensations in Area 7 than the White-British respondents. For other areas, there is not much difference.

known that almost everyone's sensation is unique, therefore, investigation of the individuality of the sensations among the respondents is necessary. A kind of statistical instrument is used to assign the respondents into specific groups based on their perceived sensations.

The K-means cluster analysis was selected to classify the respondents into groups. From the theory and the procedure of K-means cluster analysis, it reveals this analysis method is quite suitable to analyse the data from this research and to assign the respondents into groups.

5.6.2 The K-means cluster analysis of sensations

5.6.2.1 Pressure sensations

Based on K-means cluster analysis among pressure sensations, the respondents were divided into 5 cluster groups as shown in Table 5.18. The values in the table are the average value of pressure sensations on specific areas of the bra for the group. Table 5.19 shows the numbers of cases in each cluster group, and Figure 5.5 shows the distance of cases from its classification cluster value.

Table 5.18 Final cluster values of each group for pressure sensations

Pressure sensation	Cluster Group				
	1	2	3	4	5
Area 1	1	2	1	4	4
Area 2	1	3	3	5	5
Area 3	1	3	3	4	4
Area 4	1	3	4	4	3
Area 5	0	2	1	3	1
Area 6	0	2	0	3	1
Area 7	1	4	2	5	3
Area 8	1	3	1	4	2
Area 9	1	3	1	4	2

Table 5.19 Numbers of cases in each cluster group

Cluster group	Numbers of cases
1	43
2	85
3	29
4	62
5	44
Valid	263
Missing	0

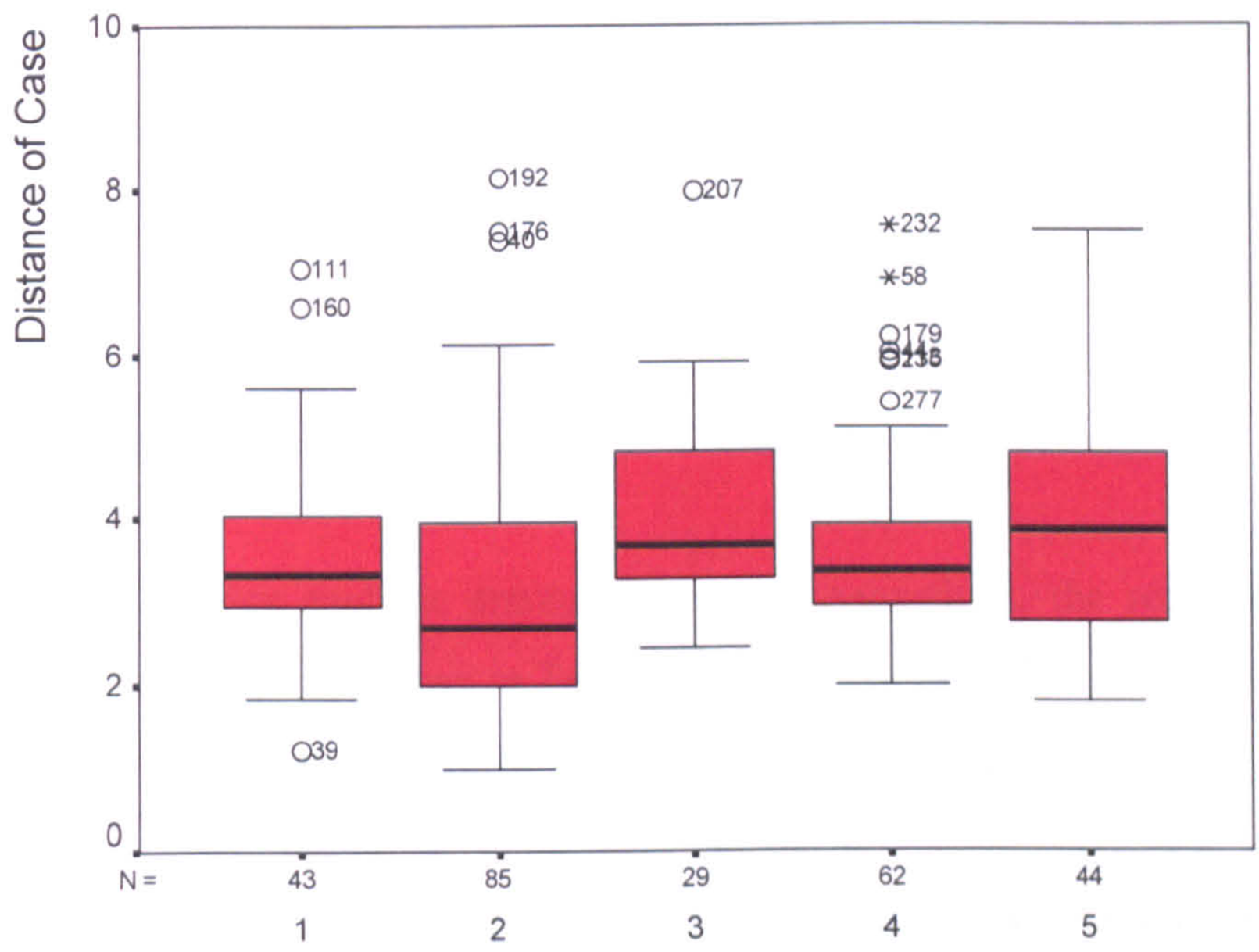


Figure 5.5 Distance of cases from its classification cluster value

Based on the results of K-means analysis, the respondents of the 5 groups can be described as below:

(1) Group 1: Respondents with insensitive pressure sensations. This type of respondents is not sensitive to the pressures caused by wearing a bra in all the focal areas of the bra. Their perceived pressure sensations are very weak.

(2) Group 2: Respondents with moderate sensitive pressure sensations. This type of respondents is somewhat sensitive to the pressures cause by wearing a bra in all the focal areas of the bra. Their perceived pressure sensations are moderate.

(3) Group 3: Respondents with moderate sensitive pressure sensations in the underband and underarm areas. This type of respondents is somewhat sensitive to the pressures in Areas 2, 3 and 4, but not so sensitive in other areas.

(4) Group 4: Respondents with sensitive pressure sensations. This type of respondents is sensitive to the pressures caused by wearing a bra in all focal areas of the bra. Their perceived pressure sensations are strong.

(5) Group 5: Respondents with sensitive pressure sensations in the underband, underarm and strap areas, but insensitive pressure sensations in other areas. This type of respondents is sensitive to the pressures in Areas 1, 2, 3, 4 and 7, but not so sensitive in other areas.

5.6.2.2 Discomfort sensations

Based on K-means cluster analysis among discomfort sensations, the respondents were divided into 5 cluster groups as shown in Table 5.20. The values in the table are the average value of discomfort sensations on specific areas of the bra for the group.

Table 5.20 Final cluster values of each group for discomfort sensations

Discomfort sensation	Cluster group				
	1	2	3	4	5
Area 1	1	6	4	0	3
Area 2	5	2	4	1	4
Area 3	4	2	2	1	4
Area 4	3	3	2	2	4
Area 5	1	0	1	0	3
Area 6	1	0	2	0	3
Area 7	4	1	4	1	4
Area 8	2	0	2	0	3
Area 9	1	2	3	1	4

Table 5.21 shows the numbers of cases in each cluster group, and Figure 5.6 shows the distance of cases from its classification cluster value.

Table 5.21 Numbers of cases in each cluster group

Cluster group	Numbers of cases
1	13
2	7
3	20
4	24
5	25
Valid	89
Missing	174

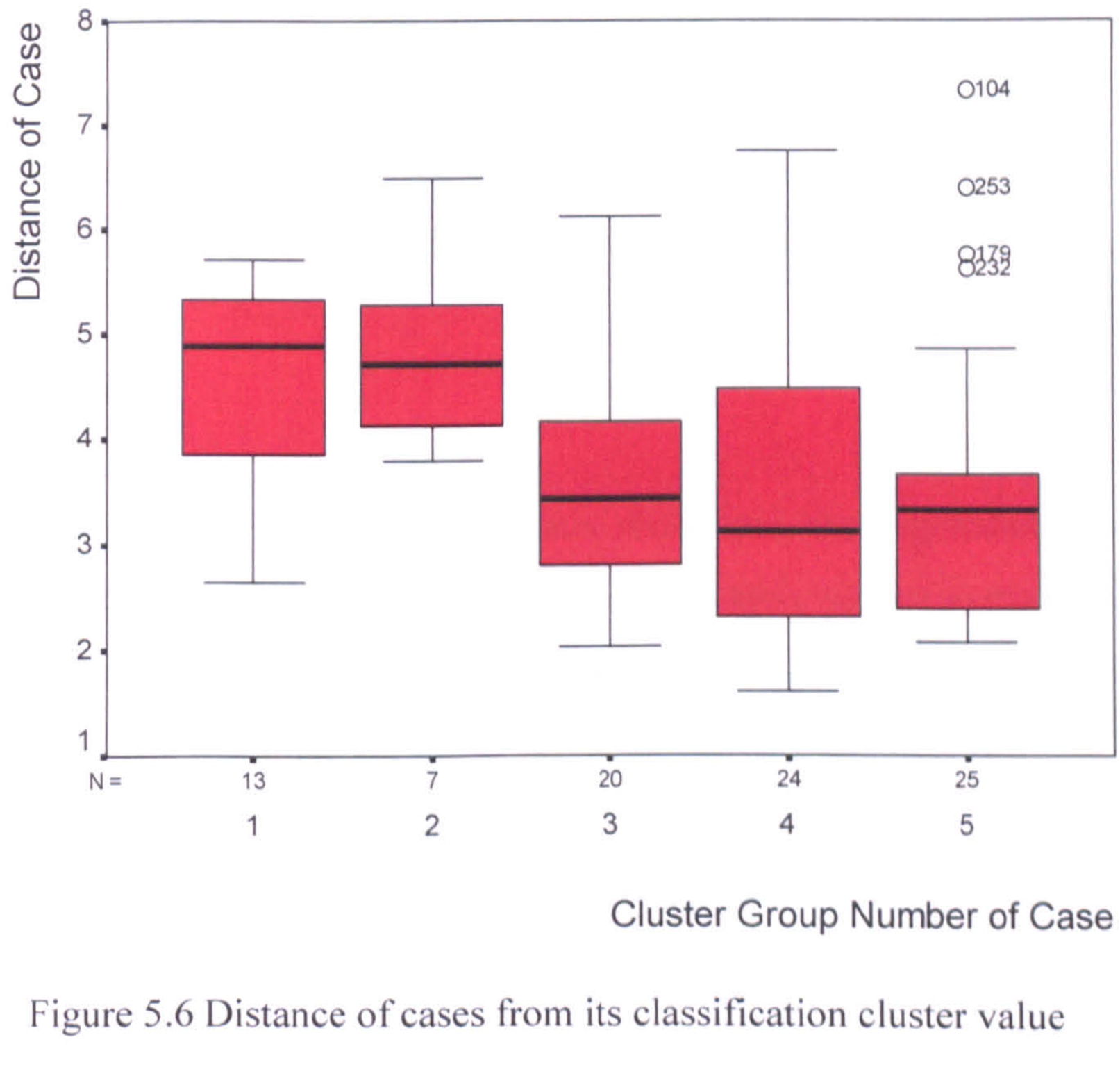


Figure 5.6 Distance of cases from its classification cluster value

Based on the results of K-means cluster, the respondents of the 5 groups can be described as below:

(1) Group 1: Respondents with stronger sensitive discomfort sensations in the underband, underarm and strap areas. This type of respondents is more sensitive to the discomfort in Areas 2, 3, 4 and 7, but not sensitive in other areas.

(2) Group 2: Respondents with strong sensitive discomfort sensations in the centre front area, not so sensitive discomfort sensations in other areas. This type of respondents have a strong discomfort sensation in Area 1, but not so sensitive in other areas.

(3) Group 3: Respondents with somewhat stronger sensitive discomfort sensations in the centre front, underband and strap areas, not so sensitive discomfort sensations in other areas. This type of respondents have a somewhat stronger discomfort sensations in Areas 1, 2 and 7, but not so sensitive in other areas.

(4) Group 4: Respondents with insensitive discomfort sensations. This type of respondents is not sensitive to the discomfort caused by wearing a bra in all the focal areas of the bra. Their perceived discomfort sensations are very weak.

(5) Group 5: Respondents with moderate sensitive discomfort sensations, this type of respondents is somewhat sensitive to the discomfort caused by wearing a bra in all focal areas of the bra. Their perceived discomfort sensations are moderate.

5.6.2.3 Pain sensations

Based on K-means cluster analysis among pain sensations, the respondents were divided into 4 groups as shown in Table 5.22. The values in the table are the average value of pain sensations on specific areas of the bra for the group. Table 5.23 shows the numbers of cases in each cluster group, and Figure 5.7 shows the distance of cases from its classification cluster value.

Table 5.22 Final cluster values of each group for discomfort sensations

Pain sensation	Cluster Group			
	1	2	3	4
Area 1	0	3	4	0
Area 2	1	3	2	5
Area 3	1	3	1	3
Area 4	2	4	2	6
Area 5	0	2	0	0
Area 6	0	2	0	0
Area 7	1	4	1	5
Area 8	0	3	0	1
Area 9	0	3	0	1

Table 5.23 Numbers of cases in each cluster group

Cluster group	Numbers of cases
1	34
2	21
3	16
4	5
Valid	76
Missing	187

Based on the results of K-means cluster, the respondents of the 4 groups can be described as below:

(1) Group 1: Respondents with insensitive pain sensations. This type of respondents is not sensitive to the pain caused by wearing a bra in all focal areas of the bra. Their perceived pain sensations are very weak.

(2) Group 2: Respondents with moderate sensitive pain sensations. This type of respondents is somewhat sensitive to the pain caused by wearing a bra in all focal areas of the bra. Their perceived pain sensations are moderate.

(3) Group 3: Respondents with somewhat stronger sensitive pain sensations in the areas around the wire, insensitive pain sensations in other areas. This type of respondents

have a somewhat stronger discomfort sensations in Areas 1, 2 and 4, but not so sensitive in other areas.

(4) Group 4: Respondents with stronger sensitive pain sensations in the underband, underarm and strap areas. This type of respondents is more sensitive to the pain in Areas 2, 3, 4 and 7, but not sensitive in other areas.

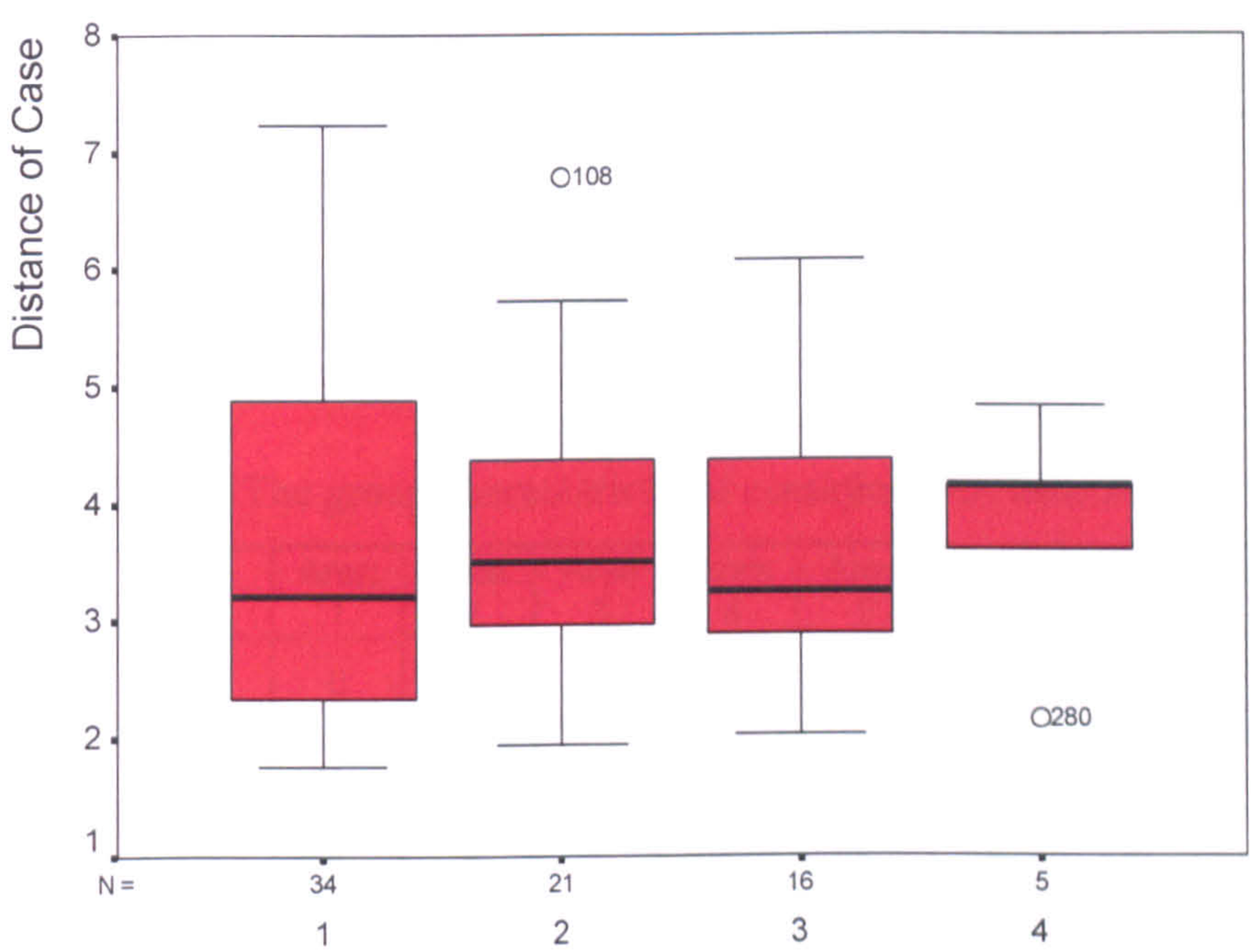


Figure 5.7 Distance of cases from its classification cluster value

5.6.2.4 The assignment of respondents

By K-means cluster analysis, the respondents were not only divided into different groups, but also assigned into the specified cluster groups. Two examples are shown as below. Two respondents were selected randomly, the Case 52 and Case 281, based on the table of cluster membership (which can be found in the Appendix H, I and J), the respondents' characteristics were obtained as shown in Table 5.24 and Table 5.25.

Table 5.24 The group characteristic of sensations for Case 52

	Group		Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Pressure Sensation	2	Case value	3	3	5	5	2	3	3	3	3
		Cluster centre	2	3	3	3	2	2	4	3	3
Discomfort Sensation	4	Case value	0	0	1	1	0	0	0	0	0
		Cluster centre	0	1	1	2	0	0	1	0	1
Pain Sensation	1	Case value	0	0	1	1	0	0	0	0	0
		Cluster centre	0	1	1	2	0	0	1	0	0

Table 5.25 The group characteristic of sensations for case 281

	Group		Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Pressure Sensation	3	Case value	0	3	3	3	2	0	3	1	0
		Cluster centre	1	3	3	4	1	0	2	1	1
Discomfort Sensation	5	Case value	3	3	3	3	5	5	5	3	3
		Cluster centre	3	4	4	4	3	3	4	3	4
Pain Sensation	2	Case value	3	3	3	3	3	3	5	3	3
		Cluster centre	3	3	3	4	2	2	4	3	3

From Table 5.24 and Table 5.25, it was discovered, respondent 52 is a kind of case with moderate sensitive pressure sensations, insensitive discomfort sensations and insensitive pain sensations in all focal areas. Respondent 281 is a kind of case with moderate sensitive pressure sensations in the underband and underarm areas, moderate sensitive discomfort sensations for all focal areas and moderate sensitive pain sensations for all focal areas.

Therefore, from the K-means cluster analysis, every respondent can be assigned into different cluster groups and their characteristics of pressure, discomfort and pain sensations can be described.

5.7 Conclusion

This chapter mainly discussed the respondents' sensations of pressure, discomfort and pain caused by wearing a bra from the survey, some useful results are obtained from using different statistical methods.

(1) The greatest pressure and discomfort sensations occur in the underband and strap areas, the perceived sensations are moderate, and the weakest pressure and discomfort sensations occur in the cup area, the perceived sensations are very weak. For the respondents who experience pain sensations, the strongest pain sensations occur in the upper underarm area, the perceived sensations are moderate, and the weakest pain sensations occur in the cup area, the perceived sensations are almost none.

(2) Women with a larger back size tend to feel weaker pressure sensations in the centre front area, whilst women take the larger cup size tend to feel stronger pressure sensations in the strap and back areas.

(3) The degrees of the sensations experienced in some areas have correlations with the extents of the misfittings in these areas.

(4) It was found that there is a strong positive correlation between the magnitudes of the same kind of sensations in different areas, e.g. a large pressure sensation in the cup area was accompanied by a large pressure sensation across the back area. There is also some degree of positive correlation between the magnitudes of the different kind of sensations in some of the areas, e.g. a large pressure sensation in the cup area was accompanied by a large discomfort sensation in the same area.

(5) When the White-British and Chinese respondents were compared, the sensations experienced are broadly similar with just small differences in some areas.

(6) By using K-means cluster analysis, the respondents are classified into 5 groups by pressure sensations, 5 groups by discomfort sensations and 4 groups by pain sensations. Within each group, the respondents displayed similar characteristics in their assessment of the sensation.

Chapter Six
Results and discussion: pressure and sensation associated with wearing a bra

6.1 Introduction

In this chapter, the data about the pressures, pressure sensations and sensations of discomfort and pain are discussed; this data was obtained from the bra pressure and sensation tests conducted at various focal areas distributed in different areas of the bra. Statistical analysis was used to investigate the characteristics of the pressure and sensation distributions in the bra and the differences of the perceived sensations for different subjects.

The investigations were focused on following issues:

(1) The relationships between the whole underbust girth and the pressure, and the whole underbust girth and the sensations in different areas of the bra for different subjects.

(2) The relationships between the pressure and sensations in different areas of the bra for different subjects.

(3) The characteristics and differences of the pressure and sensations among different subjects.

(4) The characteristics of the pressure and sensation distributions in different areas of the bra for subjects who have similar bra size measurement.

As discussed in Section 3.3.1.4, slight modifications have been made to the sample bras that the length of the back wings in the bra can be adjusted during the tests. Based on the adjustable wings, in every test, the length of the whole underbust girth was adjusted from the loosest fit to the tightest fit, different amount of pressure and sensations of pressure, discomfort and pain were obtained based on different lengths of underbust girth. Some of the underbust girths were missing for some of the subjects because these lengths are too loose or too tight for them.

Based on the data obtained from the pressure and sensation tests for different underbust girths, the relationships between the pressure and sensations presented very significant linear relationships. Therefore the statistical method of linear regression was employed in this research to investigate the characteristics of the pressures caused by wearing a bra and the bra wearers' perceived sensations.

6.2 Description of the test subjects

29 female university students were randomly selected as the test subjects. Their calculated bra sizes, preferred bra sizes and the sample bras which they were wearing in the tests are shown in Table 6.1.

From Table 6.1, it is discovered that the preferred bra size and the calculated bra size are not the same for some subjects, which means they do not always wear a bra with the size based on the measurements of their breasts.

It should be noted that one subject, subject GRT023, did not finish the tests, and therefore the data from this subject will not be included in the analysis process.

Table 6.1 The calculated, preferred and sample bra sizes of the test subjects

Subject No.	Underbust	Overbust	Calculated bra size	Her preferred bra size	Sample bra size
GRT001	77cm	89cm	34B	36A	34B
GRT002	79cm	94cm	36B	34D	34D
GRT003	77cm	97cm	34DD	32F	34E
GRT004	72cm	84cm	32B	32C	34B
GRT005	74cm	87cm	34A	32D	34C
GRT006	85cm	99cm	38B	34D	34DD
GRT007	72cm	84cm	32B	32B	34B
GRT008	72cm	84cm	32B	34B	34B
GRT009	73cm	88cm	32D	32DD	34D
GRT010	69cm	84cm	32B	32C	34B
GRT011	76cm	87cm	34A	34A	34B
GRT012	79cm	85cm	36A	34B	34B
GRT013	75cm	86cm	34A	32B	34B
GRT014	78cm	89cm	34B	34B	34B
GRT015	78cm	94cm	34D	34DD	34DD
GRT016	78cm	93cm	34D	34F	34F
GRT017	79cm	95cm	36B	34DD	34D
GRT018	78cm	99cm	34E	32D	34D
GRT019	76cm	86cm	34A	34A	34B
GRT020	86cm	96cm	38A	34D	34D
GRT021	77cm	90cm	34C	36B	34C
GRT022	71cm	83cm	32B	32B	34B
GRT023	77cm	93cm	34C	32D	34C
GRT024	77cm	90cm	34C	36B	34C
GRT025	73cm	88cm	32D	32C	34B
GRT026	77cm	98cm	34DD	34DD	34DD
GRT027	78cm	94cm	34D	34C	34C
GRT028	76cm	86cm	34A	32B	34B
GRT029	86cm	99cm	38B	36C	34D

6.3 The analysis of the pressure and sensations of one subject (as an example)

Subject GRT014, who has a 34B breast size, was selected to be used as an example to analyse the data on the pressure and sensations from the tests. Area 10, the strap area, will be discussed separately from other areas as, unlike other areas, changes in pressure and

sensations for Area 10 were caused by changing the length of the strap rather than by changing the length of the underbust girth.

6.3.1 Pressure distributions in the bra

Figure 6.1 shows the relationships between the underbust girth and the pressures on the breasts produced by wearing the bra. The red arrow on the X axis means the normal underbust Girth of sample bras with 34 underband. The same kind of arrow appears on Figure 6.2, 6.4 and 6.6. In nine focal areas of the bra, there are negative correlations between the underbust girth and the pressures. When the underbust girth increases, the overall pressures to the breasts caused by wearing the bra decreases.

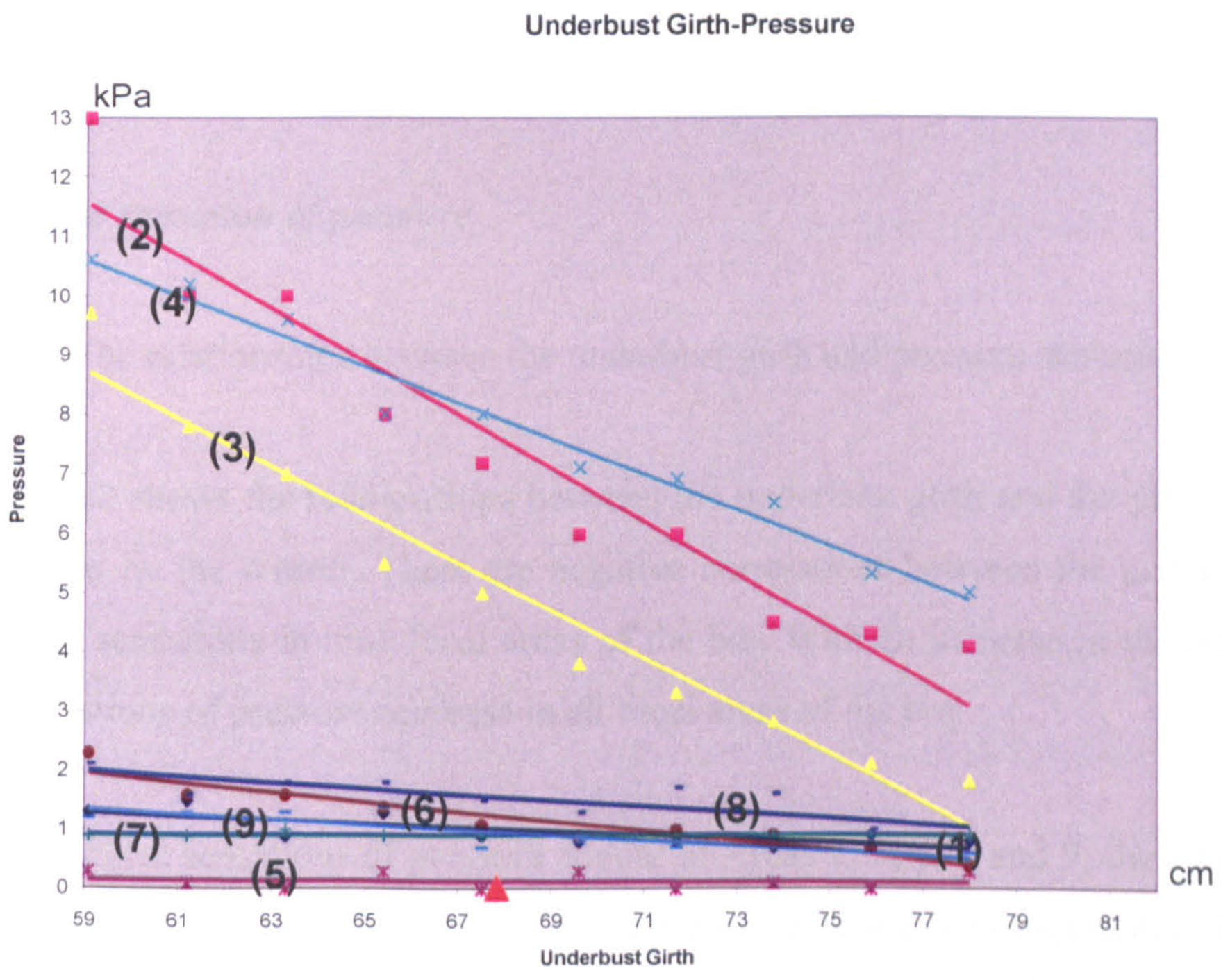


Figure 6.1 Underbust Girth – Pressure

The pressures in different areas of the bra are not the same. For all different underbust girths, the strongest pressures are found in Areas 2, 3 and 4, and the weakest pressure is in Area 5. This means that the strongest pressures appear in the underband and underwire areas of the bra, while the relatively weakest pressures are distributed in the upper part of the bra, the bra cup and the centre back.

Comparing the slopes of the lines in Figure 6.1, it is seen that with increasing underbust girth, the change of the pressure varies in the different areas of the bra. The slopes of the lines 2, 3 and 4 are the steepest; the line 5 and 7 are almost horizontal to the X-axis. This means that in the areas of the centre underband (Area 2), the lower underarm (Area 3) and the upper underarm (Area 4), a tiny change of the underbust girth will cause a large change of pressures. In other parts of the bra, the change of pressures is not so marked; this is especially so for the area of the high point of bust (Area 5) and the upper centre front (Area 7), there is almost no change of pressure when the underbust girth is changed.

6.3.2 The sensation of pressure

6.3.2.1 The relationships between the underbust girth and pressure sensations

Figure 6.2 shows the relationships between the underbust girth and the pressure sensations perceived by the wearer. There are negative correlations between the underbust girth and pressure sensations in nine focal areas of the bra. With an increase in the underbust girth, the sensations of pressure decrease in all focal areas of the bra.

The strongest sensations of pressure appear in Areas 2, 3, 4, 8 and 9; the weakest pressure sensation is experienced in Areas 5. Comparing Figure 6.2 with Figure 6.1, it is found that the pressure at Areas 8 and 9 are relatively quite weak, but the subject perceived the stronger pressure sensation. This might be due to sensitive area of sensations at the back of bra. Another characteristic of Areas 8 and 9 is that there is only a small change in the

pressure sensation over a range of looser underbust girths, but for smaller underbust girths, the rate of changes is much greater as the girth is progressively tightened.

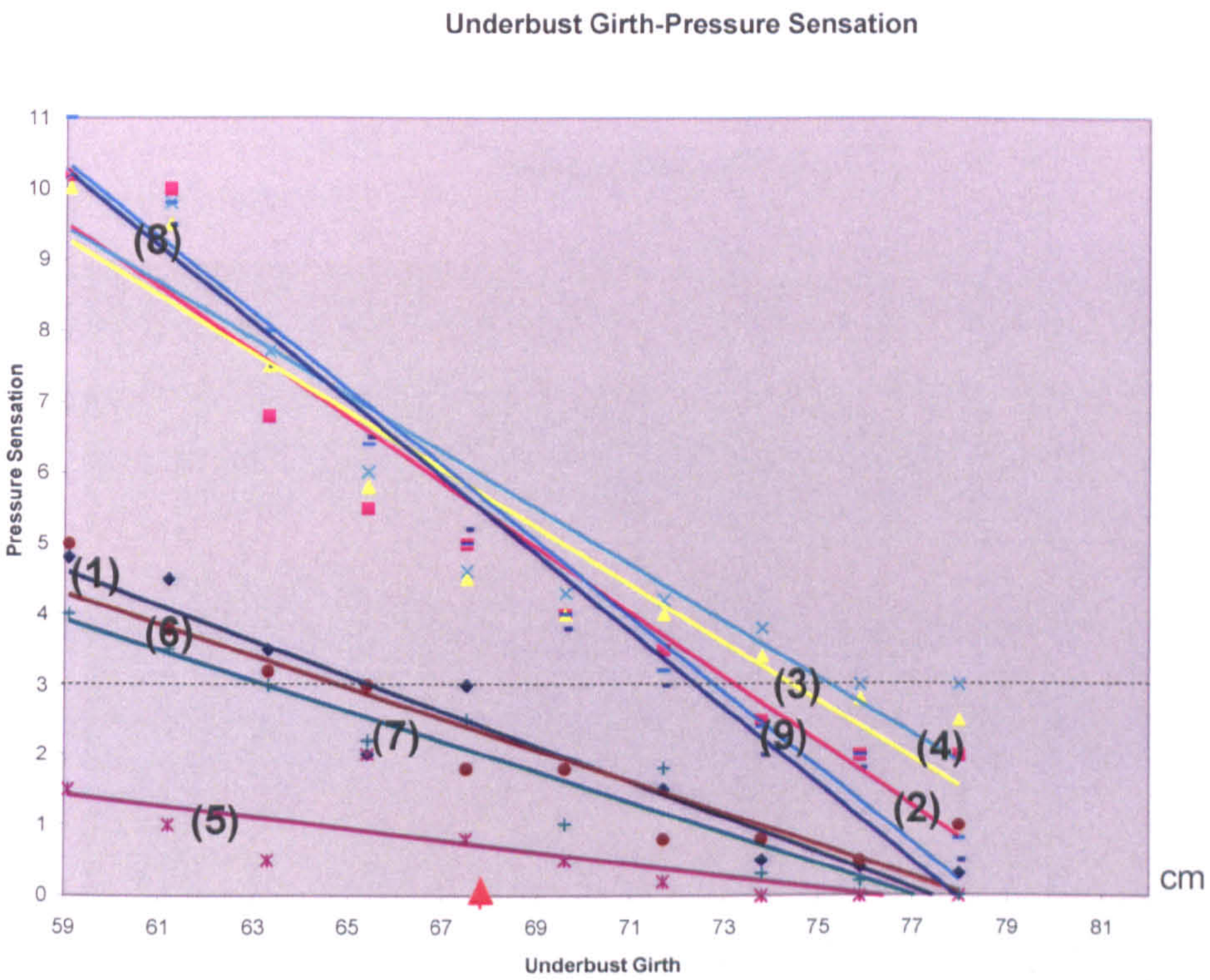


Figure 6.2 Underbust Girth – Pressure Sensation

From the Borg CR10 scale, it is known that a data rating of 3 for sensation means a moderate sensation. Therefore a horizontal dashed line was drawn at this point on the graph as a reference line. Above the line, the subject experiences stronger sensation; below the line, the subject experiences weaker sensations. Therefore, based on the reference line, it is discovered that, when the underbust girth is equal or over 75.3 cm, the pressure sensations in the nine focal areas do not exceed a rating of moderate.

6.3.2.2 The relationships between pressures and pressure sensations

Figure 6.3 shows the relationships between pressure and pressure sensations caused by wearing the bra. There are positive correlations between pressures and pressure sensations in nine focal areas of the bra. Higher pressure triggers stronger pressure sensations in the subject.

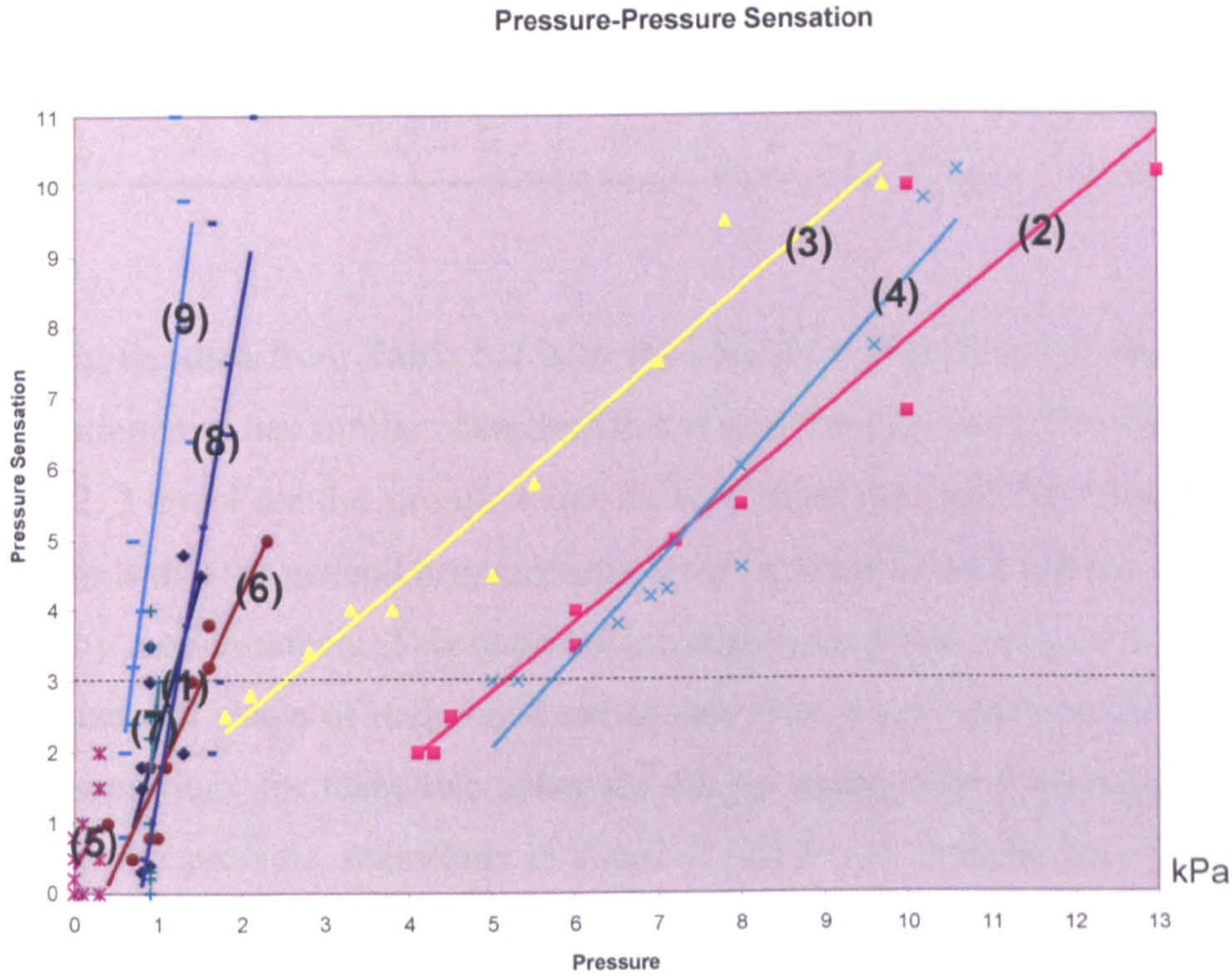


Figure 6.3 Pressure – Pressure Sensation

Comparing different areas of the bra, the same pressure can cause different pressure sensations in different areas. Compared to other areas, much higher pressures were measured in Areas 2, 3 and 4, but the sensations experienced are not much stronger than in other areas, which mean that this subject can tolerate relatively stronger pressures in these areas than in other areas. In contrast, it seems that this subject is very sensitive to pressure in Areas 8 and 9. There are only moderate correlations between the pressures and the pressure sensations in other areas.

6.3.2.3 Comparison of pressure sensations results from the survey and tests

Before the tests, the subject was asked to answer the questionnaire. For this subject, the pressure sensations from her responses to the questionnaire are shown in Table 6.2.

Table 6.2 Pressure sensations from questionnaire

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Pressure Sensation	2	5	5	5	3	3	2	1	0

Comparing the data from Table 6.2 with the data from Figure 6.2, it shows that the data from questionnaire has similar characteristics to that from the tests. The pressure sensations in Areas 2, 3 and 4 are the strongest and, in other areas are moderate. The important thing in this case is that the general pressure sensations in Areas 8 and 9 are not as strong as those obtained by measurements. This is probably because the subject always wears a bra with a suitable size and shape of underband rather than with a very tight underbust girth, so the pressure sensations for these two areas are not so strong. The plotted data in Figure 6.3 shows that the pressure sensations in Areas 8 and 9 will become very severe when the underbust girth is reduced, but when the underbust girth is the correct fit or looser, the pressure sensations are not so strong in these two areas.

6.3.3 The sensations of discomfort

6.3.3.1 The relationships between the underbust girth and discomfort sensations

Figure 6.4 shows the relationships between the underbust girth and discomfort sensations produced by wearing a bra. There are negative correlations between the underbust girth and discomfort sensations in nine focal areas of the bra. When the underbust girth is increased, the sensations of discomfort decrease in the focal areas of the bra.

The strongest sensations of discomfort appear in Areas 8 and 9; the weakest discomfort sensation appears in Areas 5. Using the reference line, it is seen that, when the underbust girth is equal or over 71.0 cm, discomfort sensations in the nine focal areas do not exceed a moderate rating.

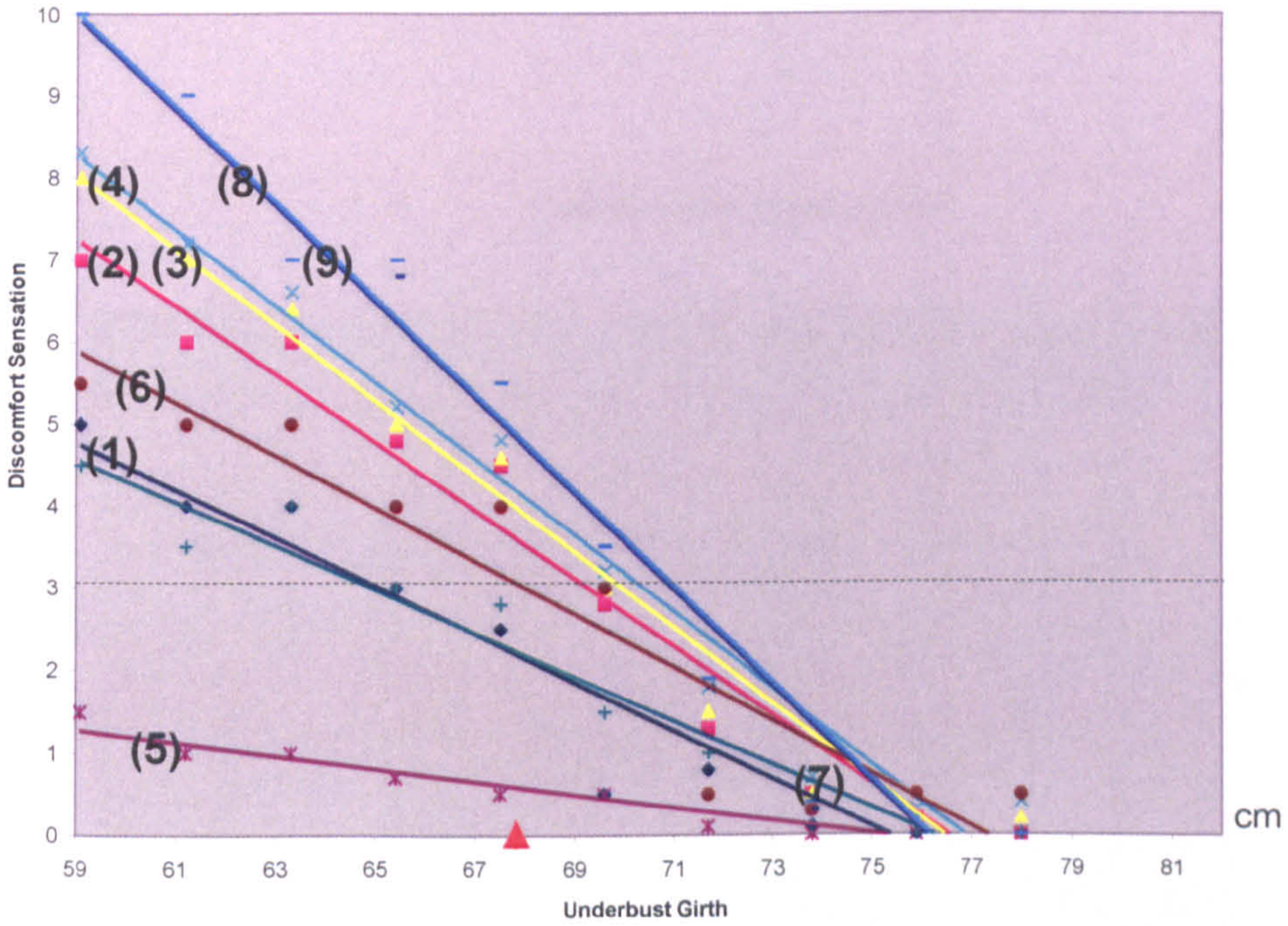


Figure 6.4 Underbust Girth – Discomfort Sensation

6.3.3.2 The relationships between pressures and discomfort sensations

Figure 6.5 shows the relationships between pressures and discomfort sensations caused by wearing the bra. There are positive correlations between pressures and discomfort sensations in nine focal areas of the bra. Higher pressures trigger stronger discomfort sensations in the subject.

Comparing the different areas of the bra, the same pressure causes different degrees of discomfort in different areas. Similar to the relationships between pressure and pressure sensation as shown in Figure 6.3, it is seen from Figure 6.5 that although much higher pressures are found in Areas 2, 3 and 4, relative to other areas, but the discomfort sensations in these three areas are not much greater than in the other 6 areas. In contrast, it seems that the subject is more sensitive to discomfort in Areas 8 and 9. There are only moderate correlations between the pressures and the discomfort sensations in the other areas.

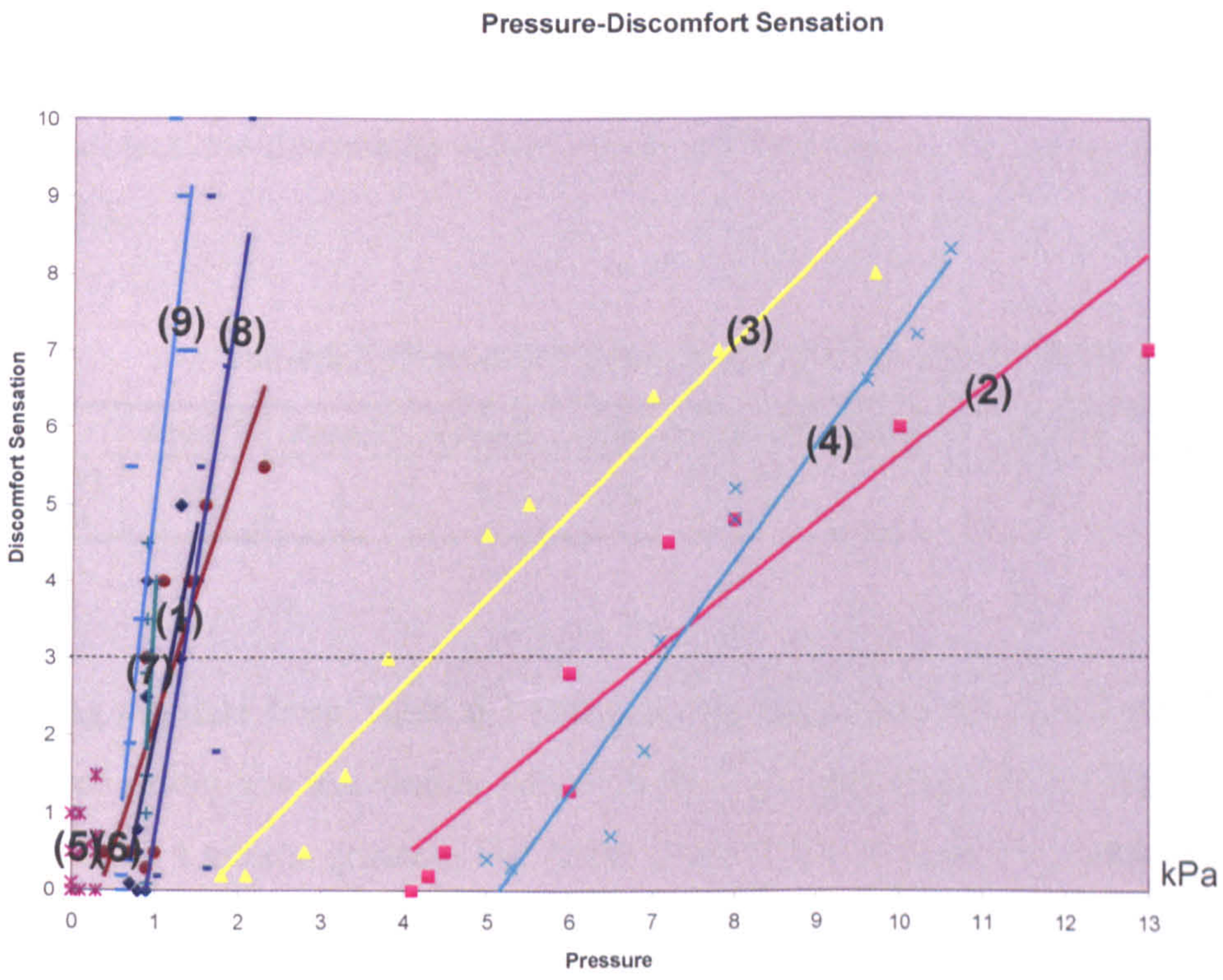


Figure 6.5 Pressure – Discomfort Sensation

All the slopes of the lines in Figure 6.5 are greater than 1, therefore it is concluded that this subject is pressure sensitive. Based on the moderate discomfort sensation rating of 3, the ideal maximum pressure for every area is shown below.

Area 1: 1.17

Area 2: 6.95

Area 3: 4.30

Area 4: 7.15

Area 5: 2.85

Area 6: 1.24

Area 7: 0.95

Area 8: 1.32

Area 9: 0.78

6.3.3.3 Comparison of discomfort sensation results from the survey and tests

For this subject, the discomfort sensations in her responses to the questionnaire are shown in Table 6.3.

Table 6.3 Discomfort sensations from the questionnaire

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Discomfort Sensation	0	1	3	3	0	0	0	0	0

Comparing the data from Table 6.3 with the data from Figure 6.4, it is seen that the data from the questionnaire has similar values to the data from tests. The pressure sensations in Areas 2, 3 and 4 are the greatest. For Areas 8 and 9, the situation is similar to that found in Section 6.3.2.3.

6.3.4 The sensation of pain

6.3.4.1 The relationships between the underbust girth and pain sensations

Figure 6.6 shows the relationships between the underbust girth and pain sensations produced by wearing the bra. There are negative correlations between the underbust girth

and pain sensations in some of the nine focal areas of the bra. With increasing of the underbust girth, the sensations of pain decrease.

The strongest sensations of pain appear in Areas 8 and 9 with a tighter underbust girth; no pain sensation is experienced in Areas 1, 2, 5, 6 and 7. It is discovered that, for all the different underbust girths, the pain sensations in all nine focal areas of the bra do not exceed the moderate sensation rating of 3.

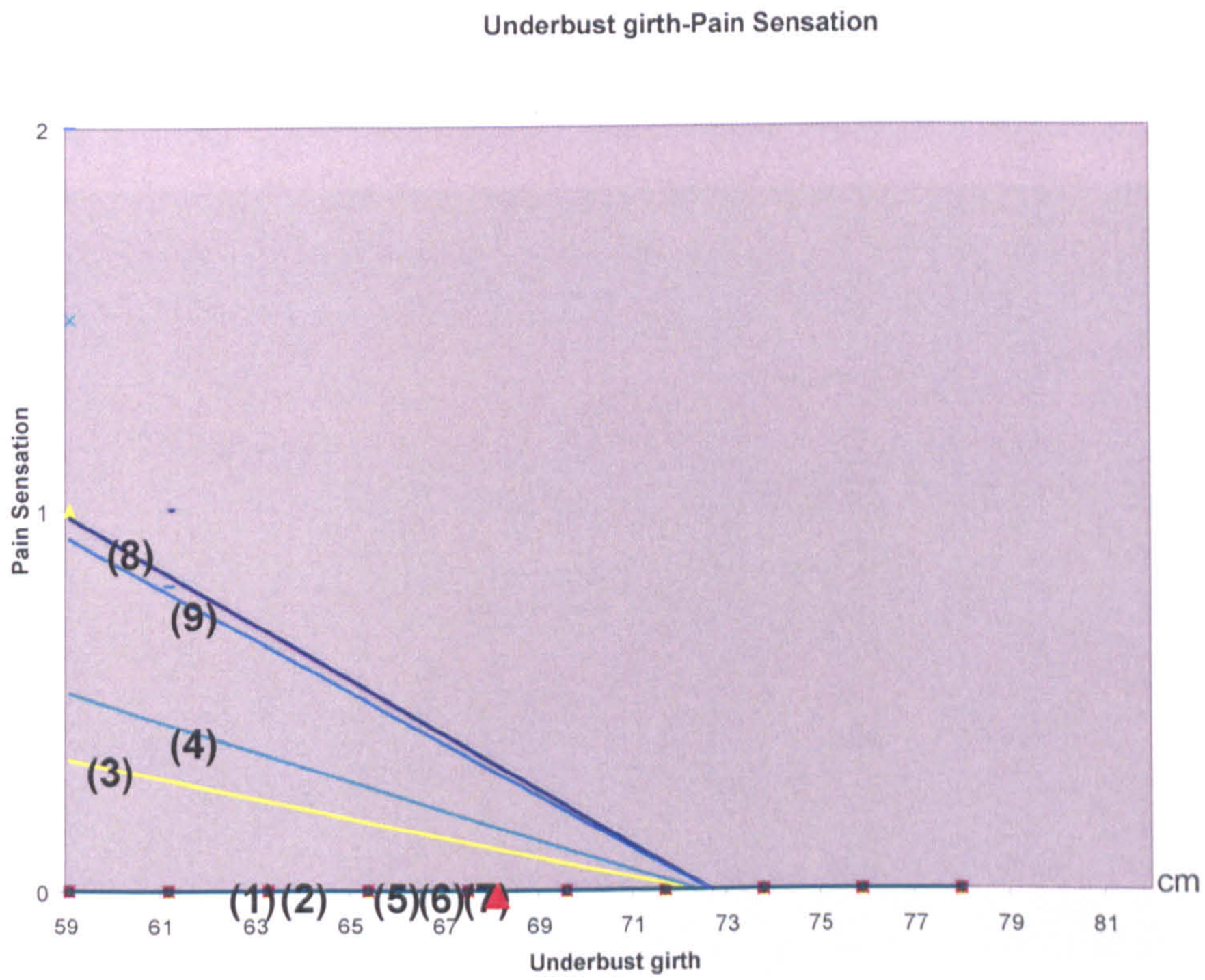


Figure 6.6 Underbust Girth – Pain Sensation

6.3.4.2 The relationships between pressures and pain sensations

Figure 6.7 shows the relationships between the pressures and the pain sensations caused by wearing the bra. There are positive correlations between pressures and pain sensations in

some of the nine focal areas of the bra. Higher pressure triggers stronger pain sensations in the subject only in Areas 3, 4, 8 and 9.

Comparing the different areas of the bra, the same pressure causes different pain sensations in different areas. For this subject, pain sensations only appear in Areas 3, 4, 8 and 9. They are very weak and do not exceed the moderate sensation rating of 3. The subject seems more sensitive to pain in Areas 8 and 9, as indicated by the higher pain sensations recorded in these areas.

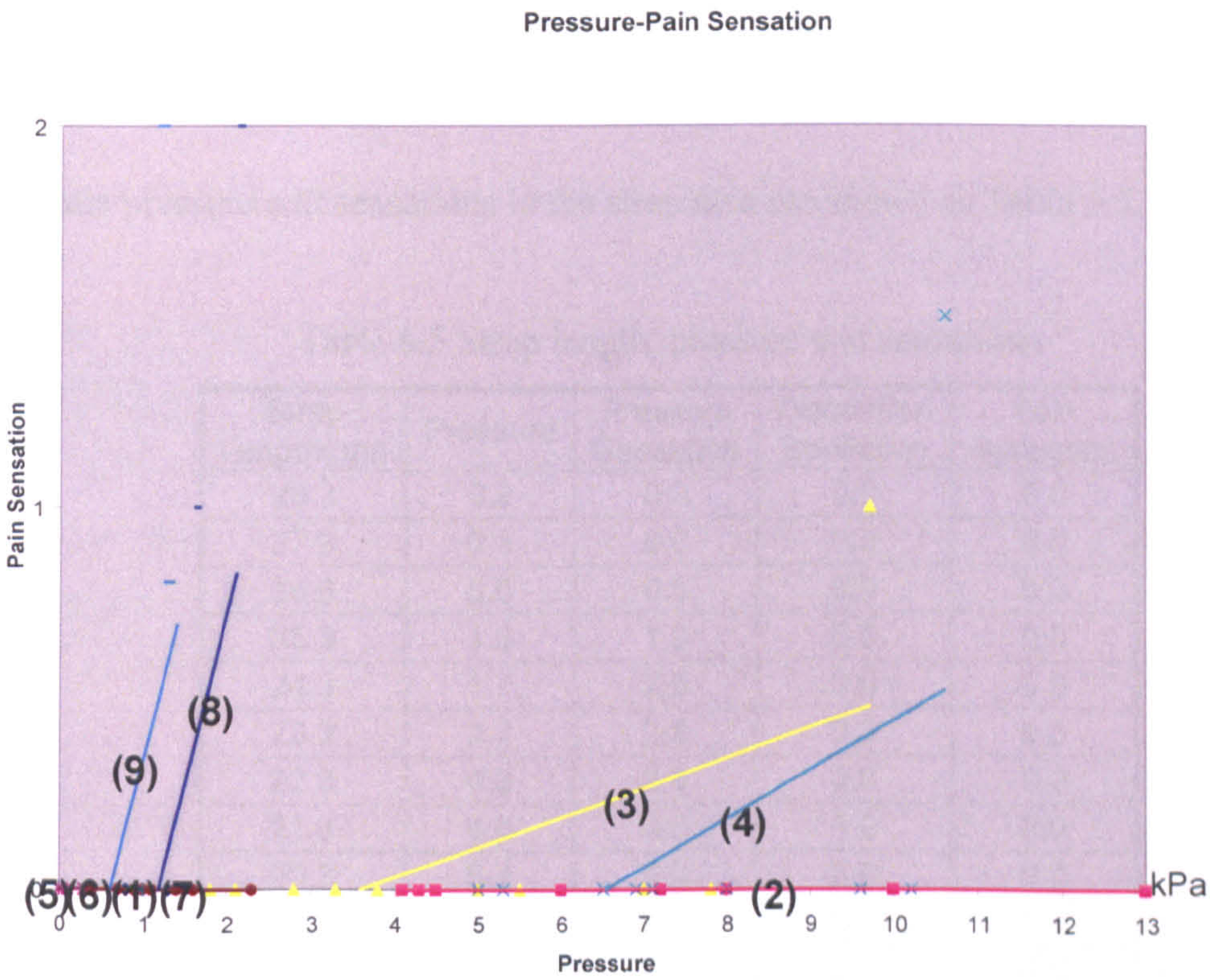


Figure 6.7 Pressure – Pain Sensation

6.3.4.3 Comparison of pain sensation results from the survey and tests

For this subject, pain sensations of her responses from the questionnaire are shown in Table 6.4.

Table 6.4 Pain sensations from the questionnaire

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Pain Sensation	0	0	0	0	0	0	0	0	0

Comparing the data from Table 6.4 with the data from Figure 6.6, it is seen that the data from the questionnaire has similar values to that from tests. There is almost no pain caused by wearing the bra when the underbust girth is correct.

6.3.5 The analysis of the pressure and sensations in the area of the strap

Data of the pressure and sensations in the strap area are shown as Table 6.5.

Table 6.5 Strap length, pressure and sensations

Strap Length(cm)	Pressure	Pressure Sensation	Discomfort Sensation	Pain Sensation
28.3	0.2	0.0	0.0	0.0
27.3	0.3	0.0	0.0	0.0
26.3	0.5	0.5	0.0	0.0
25.3	1.3	1.0	0.0	0.0
24.3	1.7	2.0	0.0	0.0
23.3	2.7	2.5	0.3	0.0
22.3	4.6	2.8	0.5	0.0
21.3	4.8	3.0	1.0	0.0
20.3	5.2	5.0	2.0	0.0
19.3	6.5	6.5	3.0	0.0
18.3	6.4	7.4	3.5	0.2
17.3	7.2	8.5	4.0	2.0

From Table 6.5, it is discovered, the ideal strap length for this subject should be longer than 21.3 cm.

6.3.6 Summary of the results

From the analysis, some useful findings were obtained.

(1) In the various individual areas of the bra, the pressure and the pressure sensations may well not be in agreement, and further the same pressure may give rise to a different sensation rating in different areas. Therefore to evaluate the fit of the bra, it is insufficient to analyse the pressure readings; the sensations of pressure, discomfort and pain as reported by the subject must also be considered.

(2) The relationships between the underbust girth and pressures are negative. The highest pressures were measured in the underband and underwire areas of the bra, and relatively weaker pressures were found in the upper part of the bra, the bra cup and the centre back.

(3) The relationships between the underbust girth and pressure sensations are negative. The strongest sensations of pressure were reported in the underband, underwire and back areas of the bra, whilst the weakest pressure sensation was reported in the high point of the bust.

(4) The relationships between the underbust girth and discomfort sensations are negative. The strongest sensations of discomfort were reported in the back areas of the bra, and the weakest discomfort sensation was reported in the high point of bust.

(5) The relationships between the underbust girth and pain sensations are negative. There were only a few reports of pain sensations in the underband, underwire and the back areas of the bra, whilst no pain sensations were reported in other areas.

(6) The area of the bra back seems to be a specially sensitive area, because, although the pressure is not high in this area, more and larger sensations of pressure, discomfort and pain were reported by the subject. There is a dramatic increase in the degree of the sensations as the underbust girth of the bra decreases. This means when the underband of the bra is quite loose, the pressure measured is quite light and the sensations reported are also weak, but when the underband of the bra is increased to a very tight size, the pressure measured is not increased very much, but the sensations experienced increase a lot. Therefore, more attention should be paid to these areas for bra fitting and design.

(7) In response to the subject's reports of discomfort and sensations of pain, the ideal maximum pressure in each area was obtained for subject 14.

(8) Using the reports of discomfort and pain sensations, the ideal minimum underbust girth for subject 14 is 71.0 cm. and ideally the strap length should be greater than 21.3 cm.

(9) The data from the questionnaire about sensations shows very similar characteristics to the data obtained in the sensation test. Thus it seems reasonable to use the results from the survey to estimate a suitable bra size for subjects. For subject 14 both her calculated and preferred bra size are 34B. Her ideal minimum underbust girth is 71.0cm which corresponds to a size 34 underband and therefore a 34B bra should be suitable for her, However it seems that subject 14 has heightened sensitivity of pressure, as both the results of the survey and the tests indicate that the 34 underbust girth caused her moderate sensations of discomfort, Therefore on the basis of these results, this subject should try a size 36 bra or, because of the strong sensation of discomfort in the underwire area, a bra with no underwiring.

6.4 The analysis of pressure and sensation for subjects by groups

Following the research methodology, it is useful to discuss the characteristics of pressure and sensation for subjects with similar bra sizes. Because the subjects were chosen randomly, the sizes of breasts are widely varying. Using the calculated bra sizes, the subjects were divided into 12 groups as shown in Table 6.6. In the following analysis, the Group 1 and Group 10 are discussed in detail as examples.

Table 6.6 Subjects groups

Group No.	Subject No.	Underbust girth	Overbust girth	Calculated bra size	Her preferred bra size	Sample bra size
1	GRT010	69cm	84cm	32B	32C	34B
	GRT022	71cm	83cm	32B	32B	34B
	GRT004	72cm	84cm	32B	32C	34B
	GRT007	72cm	84cm	32B	32B	34B
	GRT008	72cm	84cm	32B	34B	34B
2	GRT009	73cm	88cm	32D	32DD	34D
	GRT025	73cm	88cm	32D	32C	34B
3	GRT005	74cm	87cm	34A	32D	34C
	GRT013	75cm	86cm	34A	32B	34B
	GRT019	76cm	86cm	34A	34A	34B
	GRT028	76cm	86cm	34A	32B	34B
	GRT011	76cm	87cm	34A	34A	34B
4	GRT001	77cm	89cm	34B	36A	34B
	GRT014	78cm	89cm	34B	34B	34B
5	GRT024	77cm	90cm	34C	36B	34C
	GRT021	77cm	90cm	34C	36B	34C
	GRT023	77cm	93cm	34C	32D	34C
6	GRT003	77cm	97cm	34DD	32F	34E
	GRT026	77cm	98cm	34DD	34DD	34DD
7	GRT016	78cm	93cm	34D	34F	34F
	GRT015	78cm	94cm	34D	34DD	34DD
	GRT027	78cm	94cm	34D	34C	34C
8	GRT018	78cm	99cm	34E	32D	34D
9	GRT012	79cm	85cm	36A	34B	34B
10	GRT002	79cm	94cm	36B	34D	34D
	GRT017	79cm	95cm	36B	34DD	34D
11	GRT020	86cm	96cm	38A	34D	34D
12	GRT006	85cm	99cm	38B	34D	34DD
	GRT029	86cm	99cm	38B	36C	34D

6.4.1 The analysis of Group 1

This group include subjects GRT010, GRT022, GRT004, GRT007 and GRT008. As stated before, each subject in this group can be analysed as an individual, but in this section, their data were compared to discover both the common characteristics and the differences among the subjects with similar bra sizes.

The relationships between the underbust girth and pressure are shown in Figure 6.8. It is found that the magnitude of the pressures and their distributions in the nine focal areas of the bra followed the same trend among these 5 subjects. There are negative correlations between the underbust girth and pressure in most of the focal areas of the bra. When the underbust girth increases, pressures to the breasts caused by wearing the bra decreases. The highest pressure appears in the underband and underwire areas of the bra, and relatively weaker pressures are distributed in the upper parts of the bra, the bra cup and the centre back.

It is seen from the slopes of the lines in Figure 6.8 that the changes of the pressures in the different areas of the bra vary when the underbust girth is increased. The slopes of the lines 2, 3 and 4 are steepest, which means that small change in the underbust girth can cause a large change in pressures in the areas of the centre underband (Area 2), the lower underarm (Area 3) and the upper underarm (Area 4); but in other parts of the bra, changes in pressures are not so marked.

The magnitudes and distributions of the pressures in different areas of the bra are similar for these 5 subjects. For Subject 22, the pressures in Areas 2 and 4 are slightly greater than for the other subjects. It is concluded, therefore, that the magnitudes and the distributions of pressures due to wearing a bra are similar for subjects who have similar bra sizes.

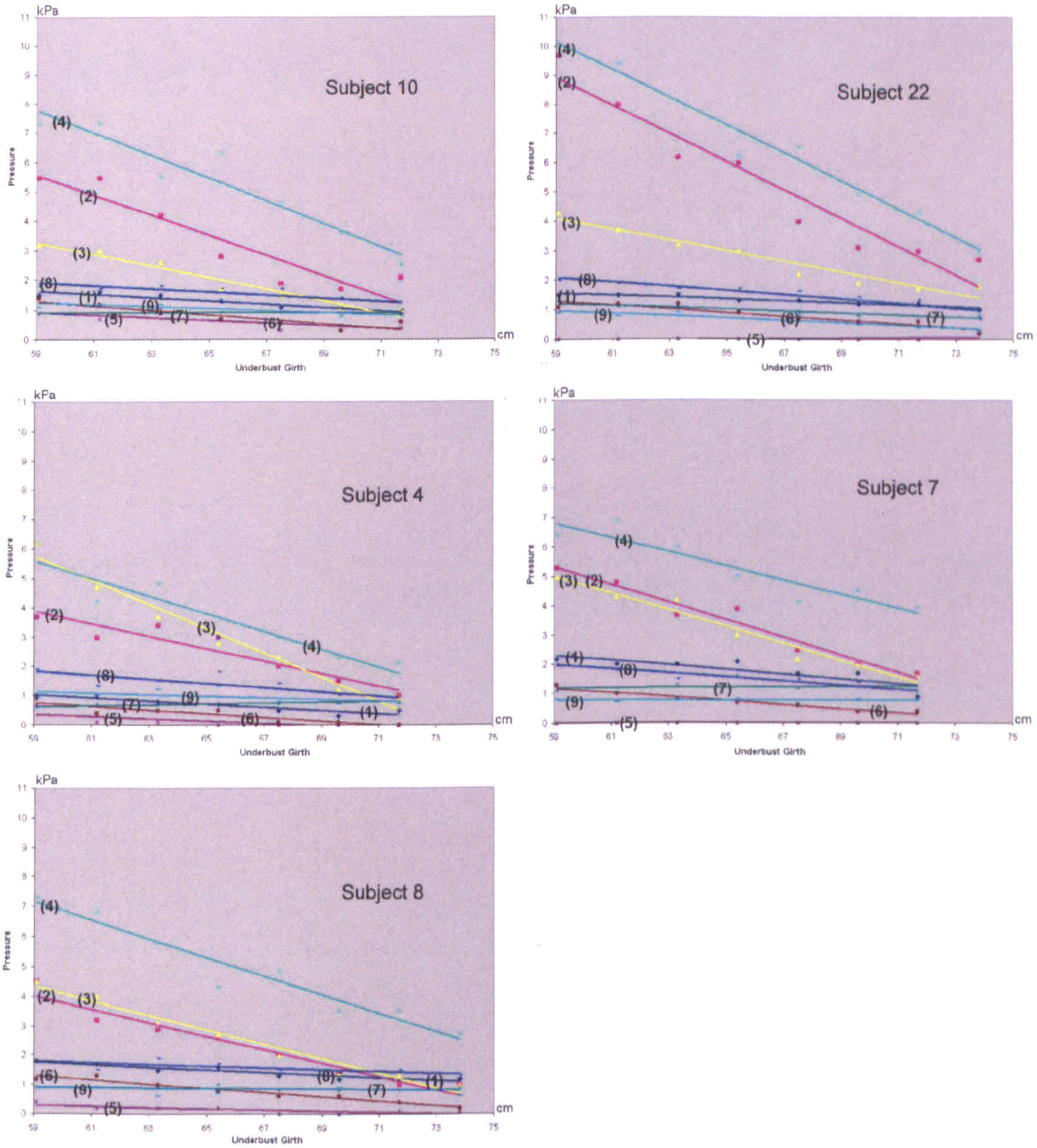


Figure 6.8 Underbust girth - Pressure of Subjects 10, 22, 4, 7 and 8 in Group 1

The relationships between the underbust girth and pressure sensations are shown in Figure 6.9. The relationships between pressures and pressure sensations are shown in Figure 6.10.

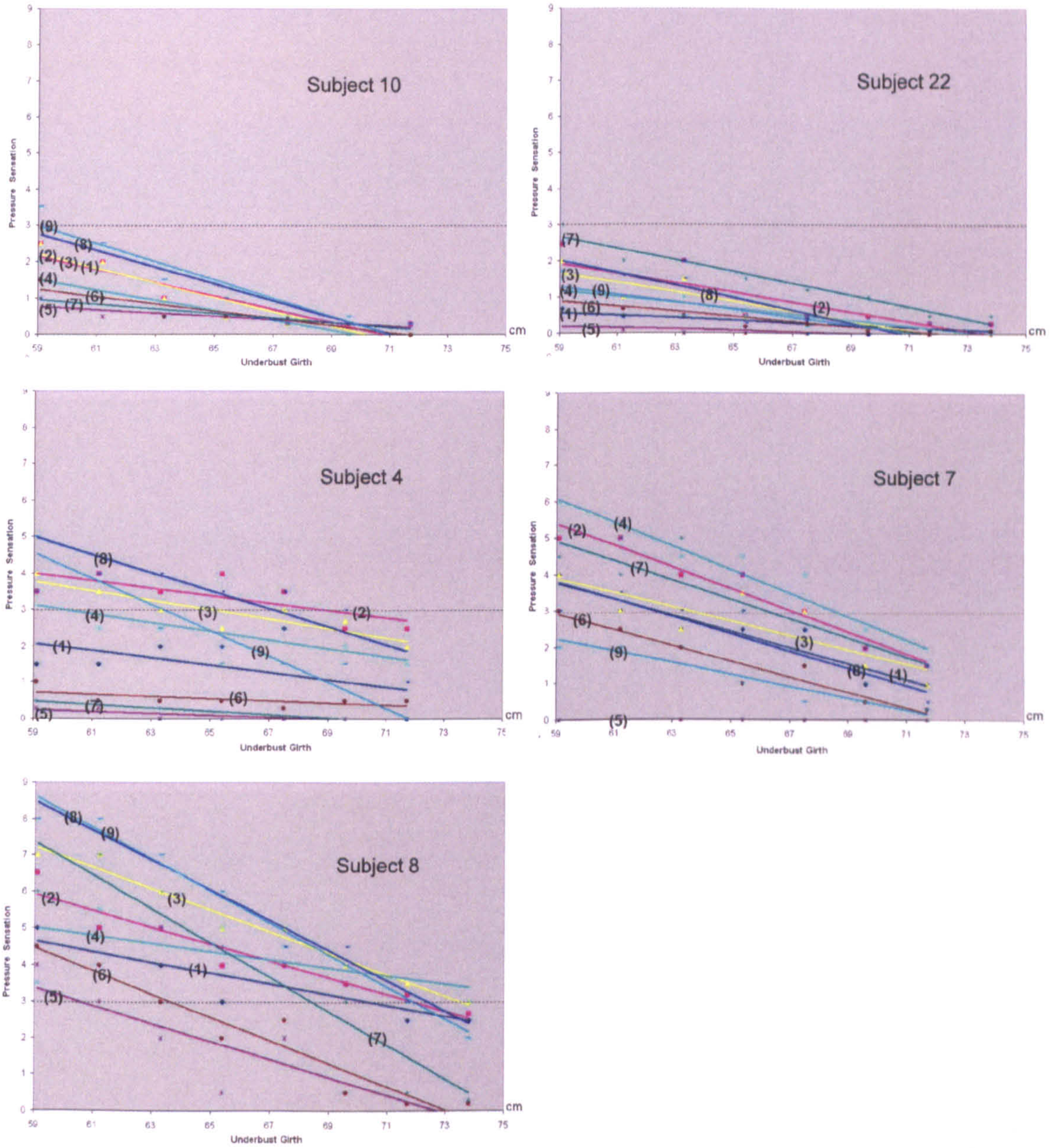


Figure 6.9 Underbust girth - Pressure sensation of Subjects 10, 22, 4, 7 and 8 in Group 1

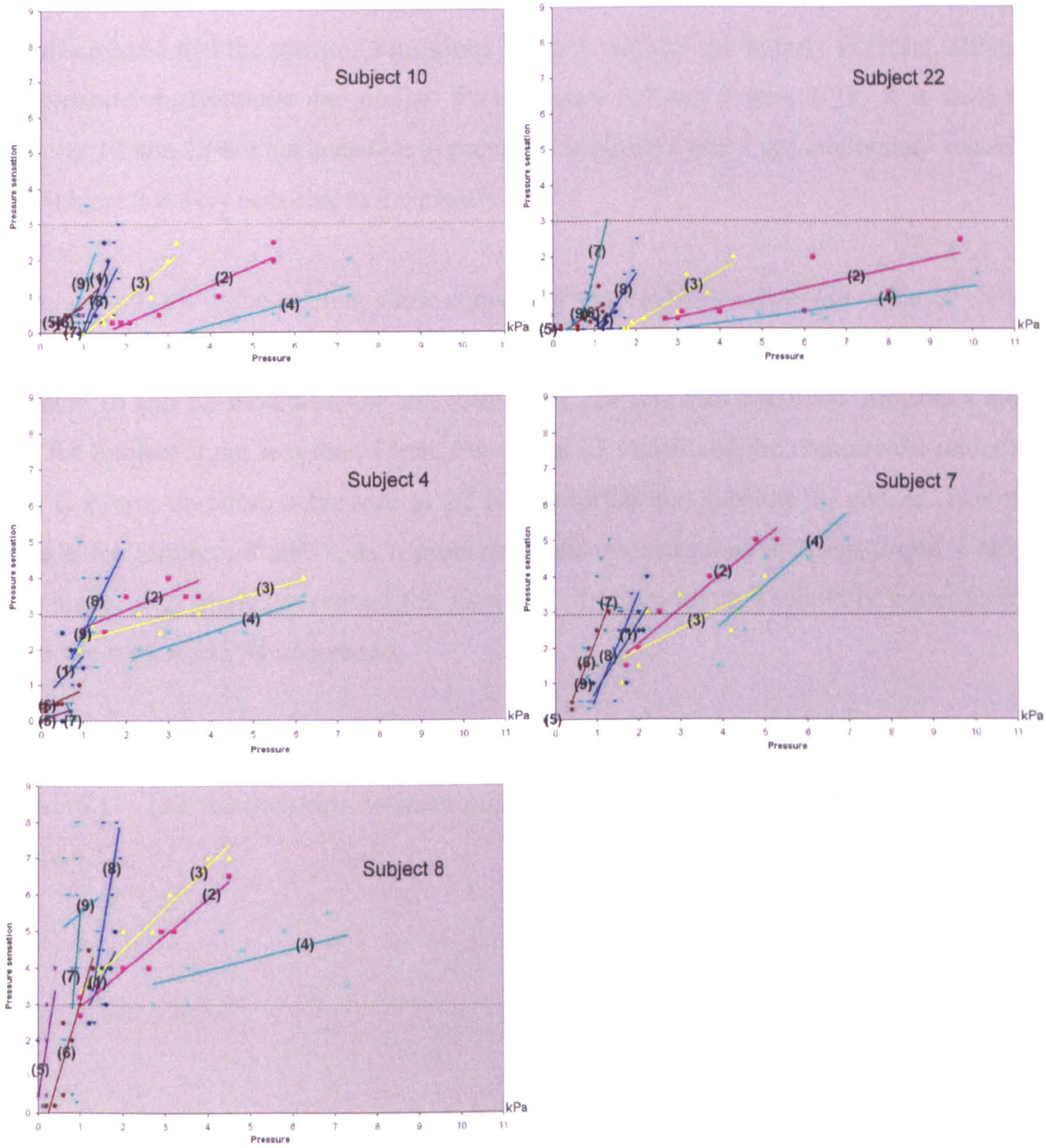


Figure 6.10 Pressure - Pressure sensation of Subjects 10, 22, 4, 7 and 8 in Group 1

Plotting the readings reveals negative correlations between the underbust girth and pressure sensations, but positive correlations between pressures and pressure sensations in the nine focal areas of the bra for all 5 subjects. The subjects can tolerate stronger pressure in Areas 2, 3 and 4 than in other areas.

It is discovered that the pressure sensations of the 5 subjects are entirely different, although the pressure distributions are similar. From Figure 6.9 and Figure 6.10, it is seen that Subjects 10 and 22 are not sensitive to pressure, Subjects 4 and 7 are moderately sensitive, and Subject 8 is very sensitive to the pressure.

In Figure 6.9, using the reference line equivalent to a pressure sensitivity value of 3, it is seen that if the pressure sensation is not to exceed moderate, then the underbust girths for Subjects 10 and 22 should be not less than 59cm, not less than 69cm for Subjects 4 and 7 and, for Subject 8 not less than 75cm. For a size 32 underband the commercial underbust girth is 67cm; therefore a bra size of 32 is appropriate for Subjects 10 and 22. It is also suitable for Subjects 4 and 7, as it produces pressure sensations in Areas 2 and 4 only a little higher than moderate rating of 3. However, for Subjects 8, it would be better to try a larger bra with a size 34 underband.

The relationships between the underbust girth and discomfort sensations are shown in Figure 6.11. The relationships between pressures and discomfort sensations are shown in Figure 6.12.

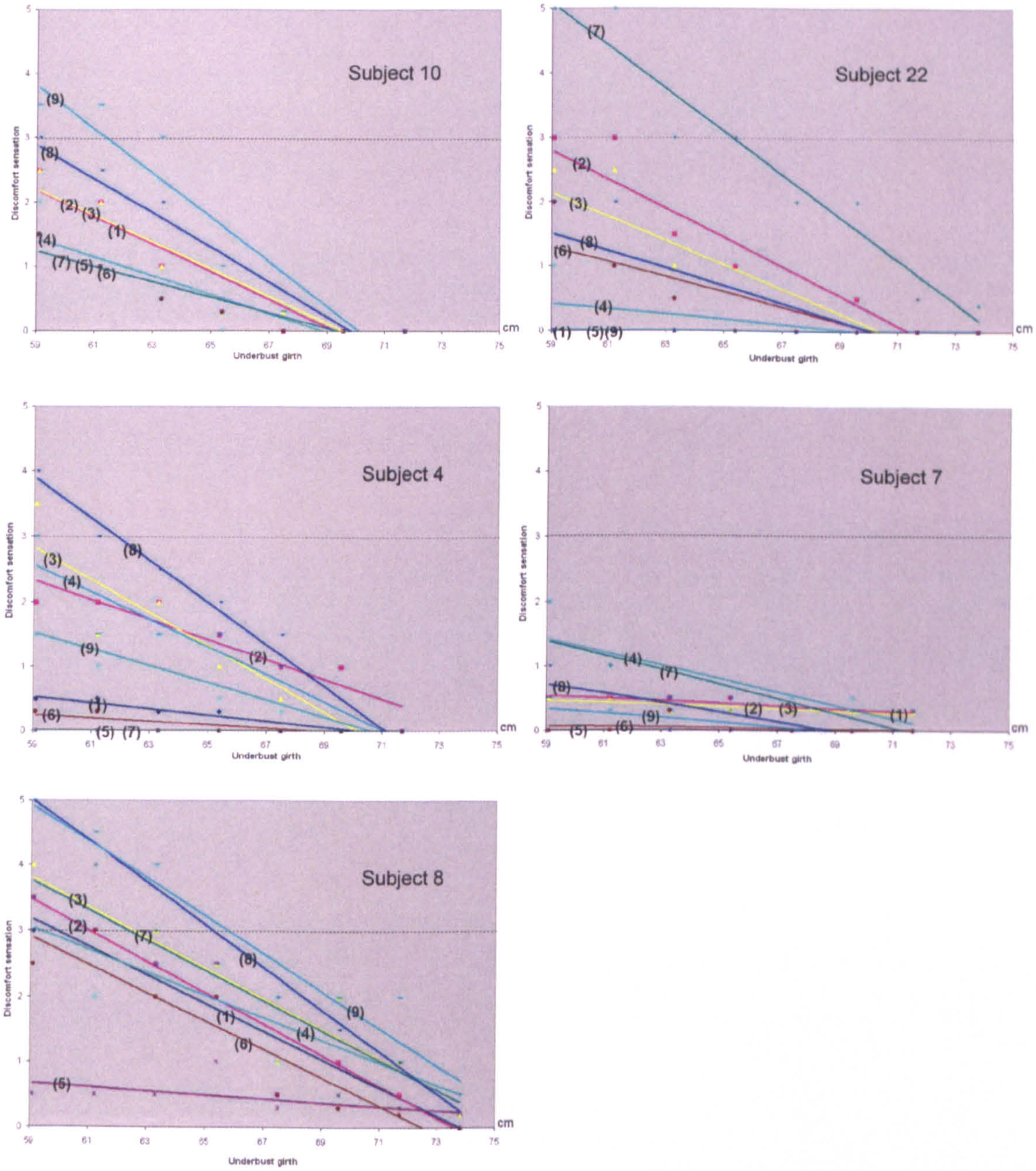


Figure 6.11 Underbust girth-Discomfort sensation of Subjects 10, 22, 4, 7 and 8 in Group 1

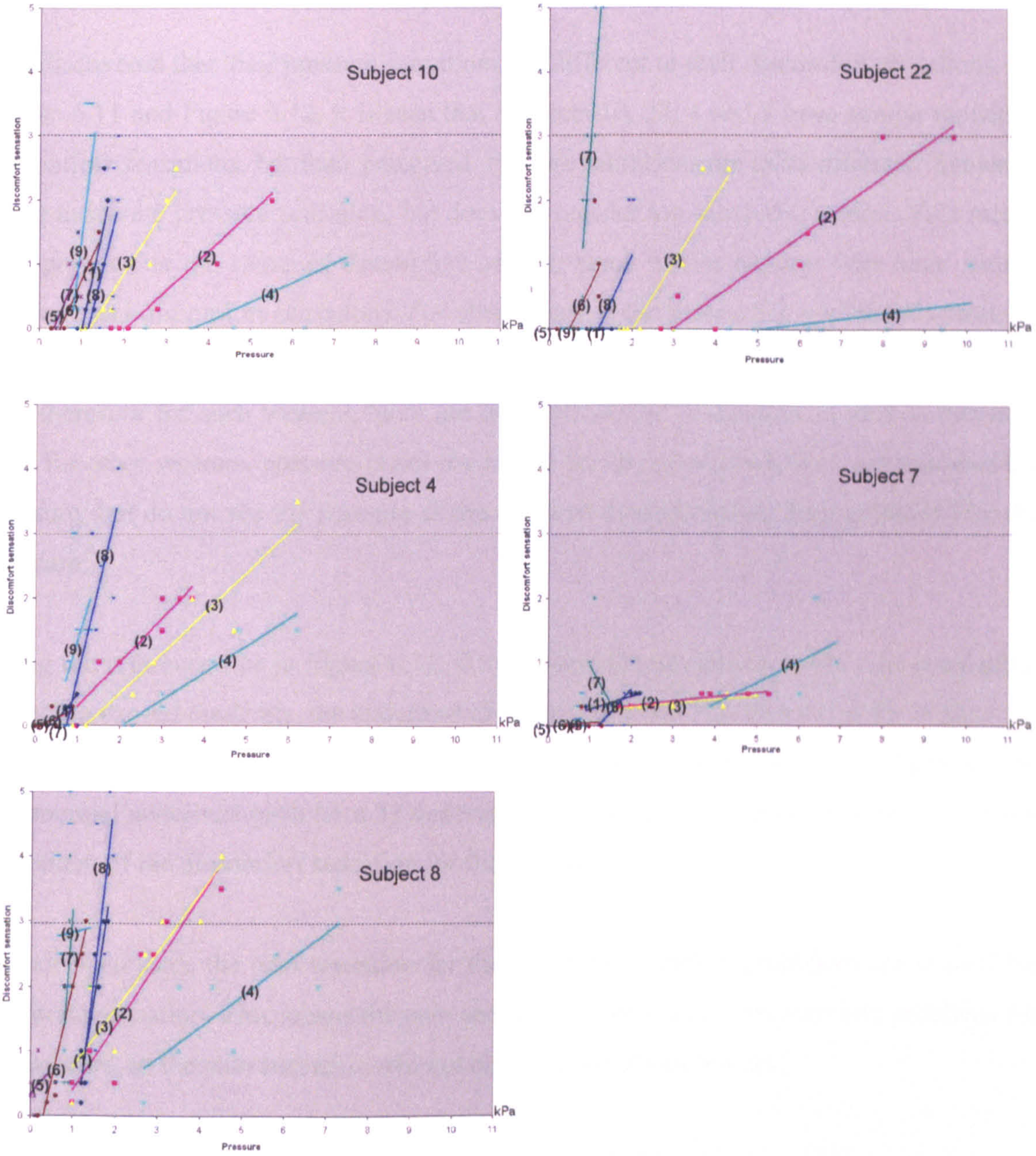


Figure 6.12 Pressure - Discomfort sensation of subjects 10, 22, 4, 7 and 8 in Group 1

There are negative correlations between the underbust girth and the discomfort sensations, but positive correlations between pressures and discomfort sensations in nine focal areas of the bra for all 5 subjects. In comparison to other areas, the subjects are more tolerant of pressure in Areas 2, 3 and 4, where the discomfort sensations are weaker.

It is discovered that their pressure sensations are different to their discomfort sensations. In Figure 6.11 and Figure 6.12, it is seen that Subjects 10, 22, 4 and 8 have similar moderate discomfort sensations, but their perceived pressure sensations are quite different. Subject 7 has a moderate pressure sensation, but does not register too much discomfort. This means that pressure is the cause of discomfort only to some of the wearers who have similar pressure and discomfort sensations. For other wearers, the pressure is not the only cause of discomfort; there are probably other factors which cause discomfort in some of areas of the bra, therefore for such wearers, there are other discomfort sensations as well as pressure. And for other wearers, pressure is not the reason for the discomfort, they can perceive the pressure, but do not see the pressure as the cause of the discomfort, they probably like the pressure.

Using the reference line in Figure 6.11, if the discomfort sensations in the nine focal areas are not to exceed moderate, the underbust girth should be not less than 61cm for Subject 10, 65cm for Subject 22, 61cm for Subject 4, 59 for Subject 7 and 66cm for Subject 8. The commercial underbust girth for a 32 underband bra is 67cm. Therefore the size of 32 is not a problem of the discomfort sensation for the 5 subjects.

For all 5 subjects, the pain sensation for the different underbust girth does not exceed the moderate sensation. This means the pain sensation is not enough to cause any problems for the wearers, so the pain sensation will not be discussed at this project.

Finally, the strap area is discussed. Figure 6.13 shows the relationships between the strap length and pressures for the 5 subjects. There are negative correlations between the strap length and pressures. It also shows different subjects experience different pressures for the same strap length; this may be due to the different shapes of the shoulders. The similar slopes of the lines for the relationship between length and pressure indicate that the amount of the increase of pressures caused by decreasing the strap length is similar among the subjects.

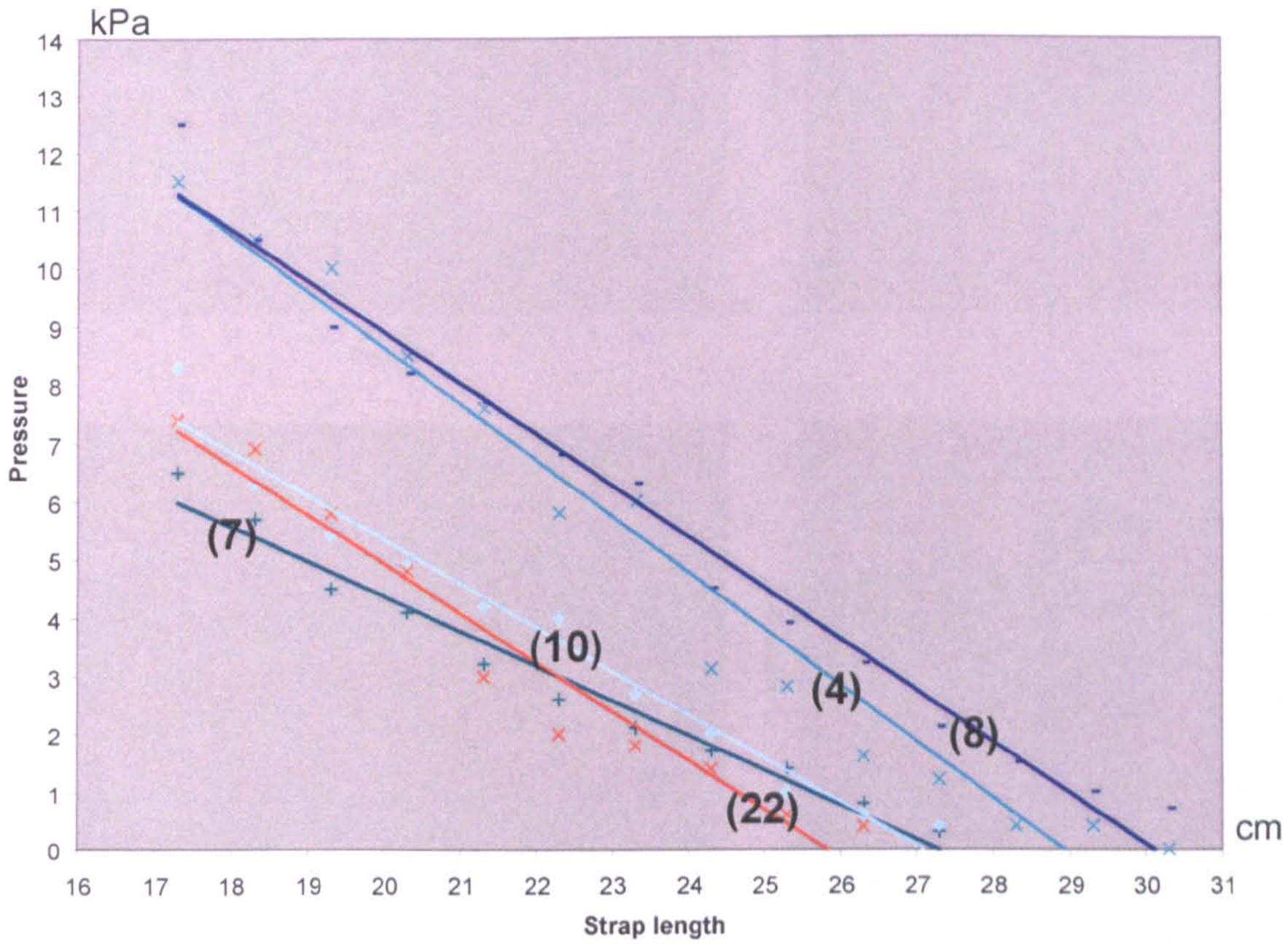


Figure 6.13 Strap length - Pressure for Subjects 10, 22, 4, 7 and 8 in Group 1

Figure 6.14 shows the relationships between the strap length and the three sensations, and between pressure and the sensations. There are negative correlations between the strap length and the sensations, and positive correlations between pressures and the sensations. It is seen that the smallest strap lengths so that the sensations do not exceed the moderate rating are quite different for the different subjects, but the measured pressures are not so different. It also shows that pain sensations in this area are not big enough to cause problems.

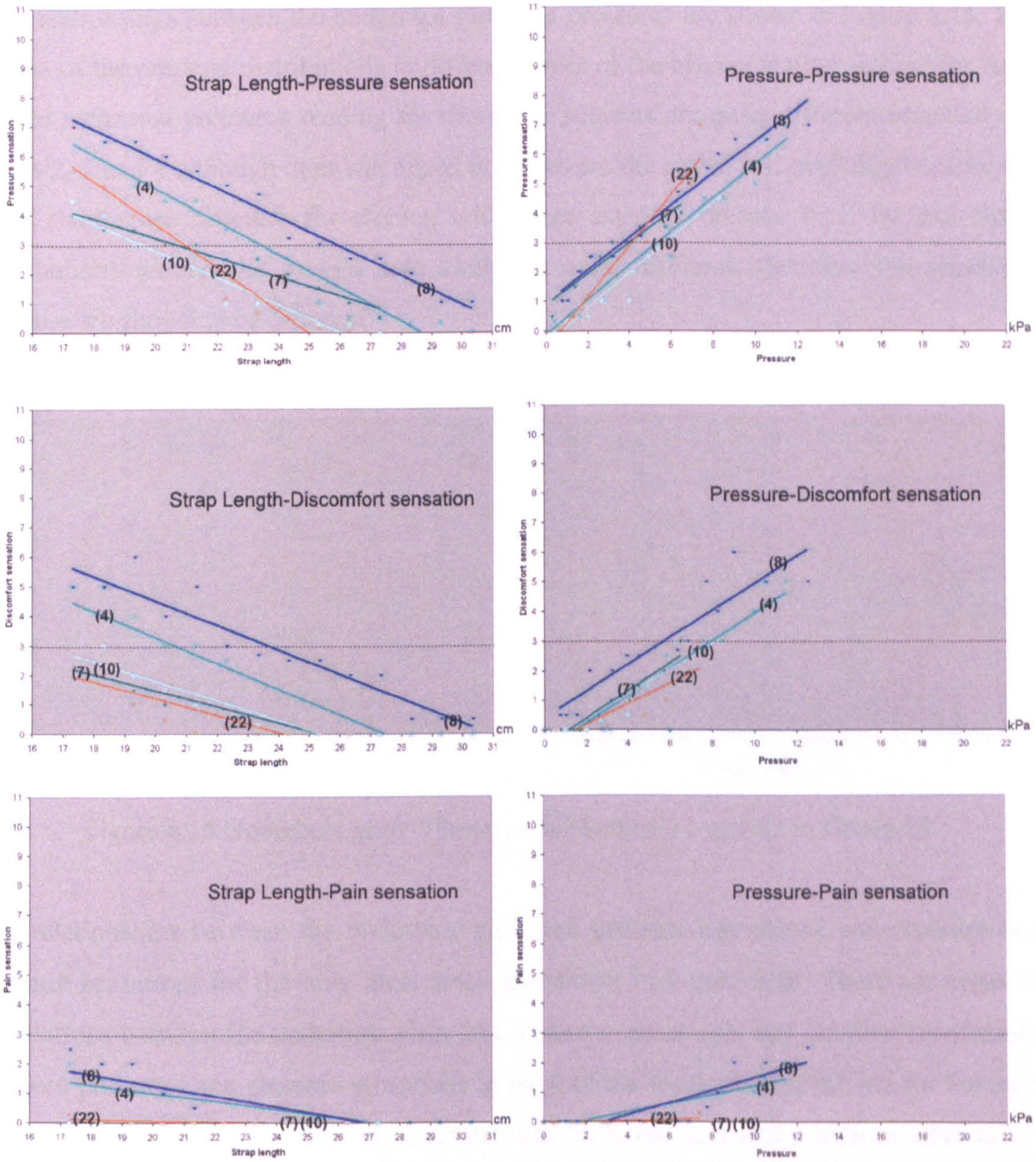


Figure 6.14 Strap length, Pressure - Sensations for Subjects 10, 22, 4, 7 and 8 in Group 1

6.4.2 The analysis of Group 10

This group is comprised of subjects GRT002 and GRT017.

The relationships between the underbust girth and pressures are shown in Figure 6.15. The graphs of the pressure distributions in different areas of the bra are similar, except for Area 4. The measured pressures reading for these two subjects are quite different especially in Areas 2, 3 and 4 although their calculated bra sizes are the same. It is probably because the body shapes are different for women with large sizes of breasts, their fat and tissue distributions around the breasts area could be quite different, therefore the measured pressure are shown to be different.

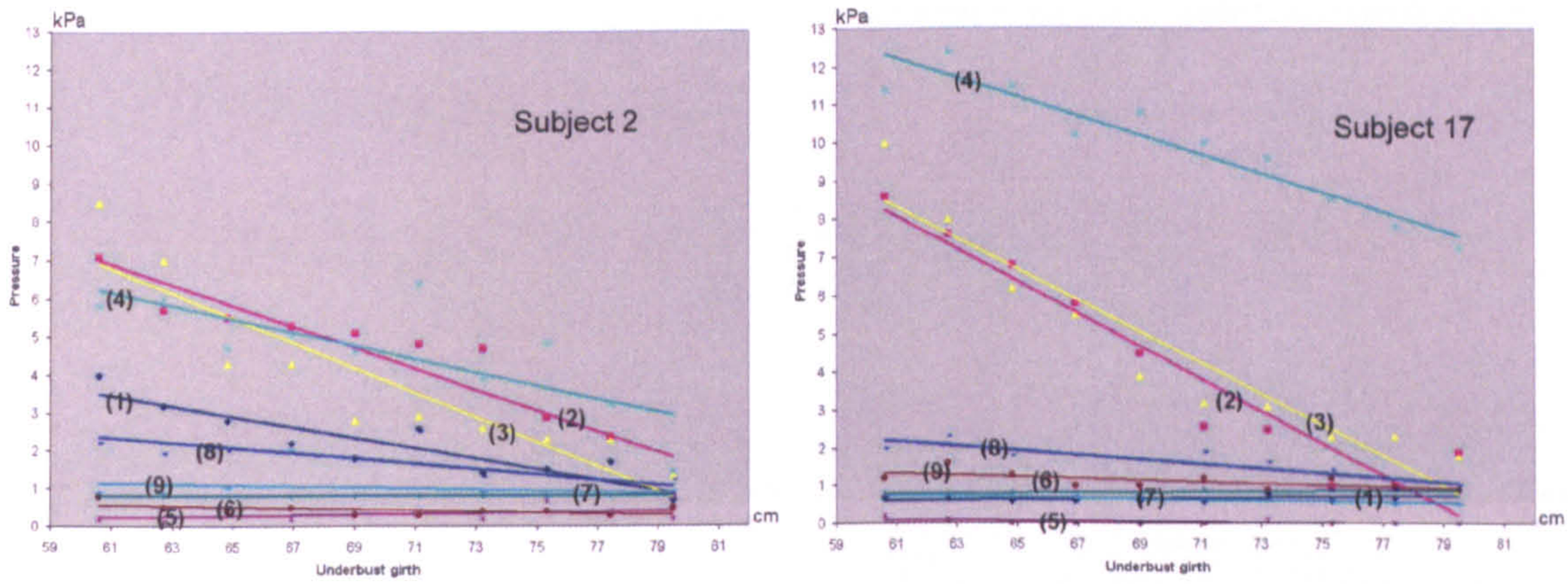


Figure 6.15 Underbust girth – Pressure for Subjects 2 and 17 in Group 10

The relationships between the underbust girth and pressure sensations, and pressure and pressure sensations for the nine focal areas are shown in Figure 6.16. There are negative correlations between the underbust girth and pressure sensations, and positive correlations between pressures and pressure sensations in most of the focal areas of the bra for Subjects 2 and 7. The subjects can stand stronger pressure in Areas 2, 3 and 4 than in other areas. But greater pressure sensations were experienced in Areas 8 and 9 than in other areas; this means that women with big bra sizes are more sensitive to the pressure in these two areas.

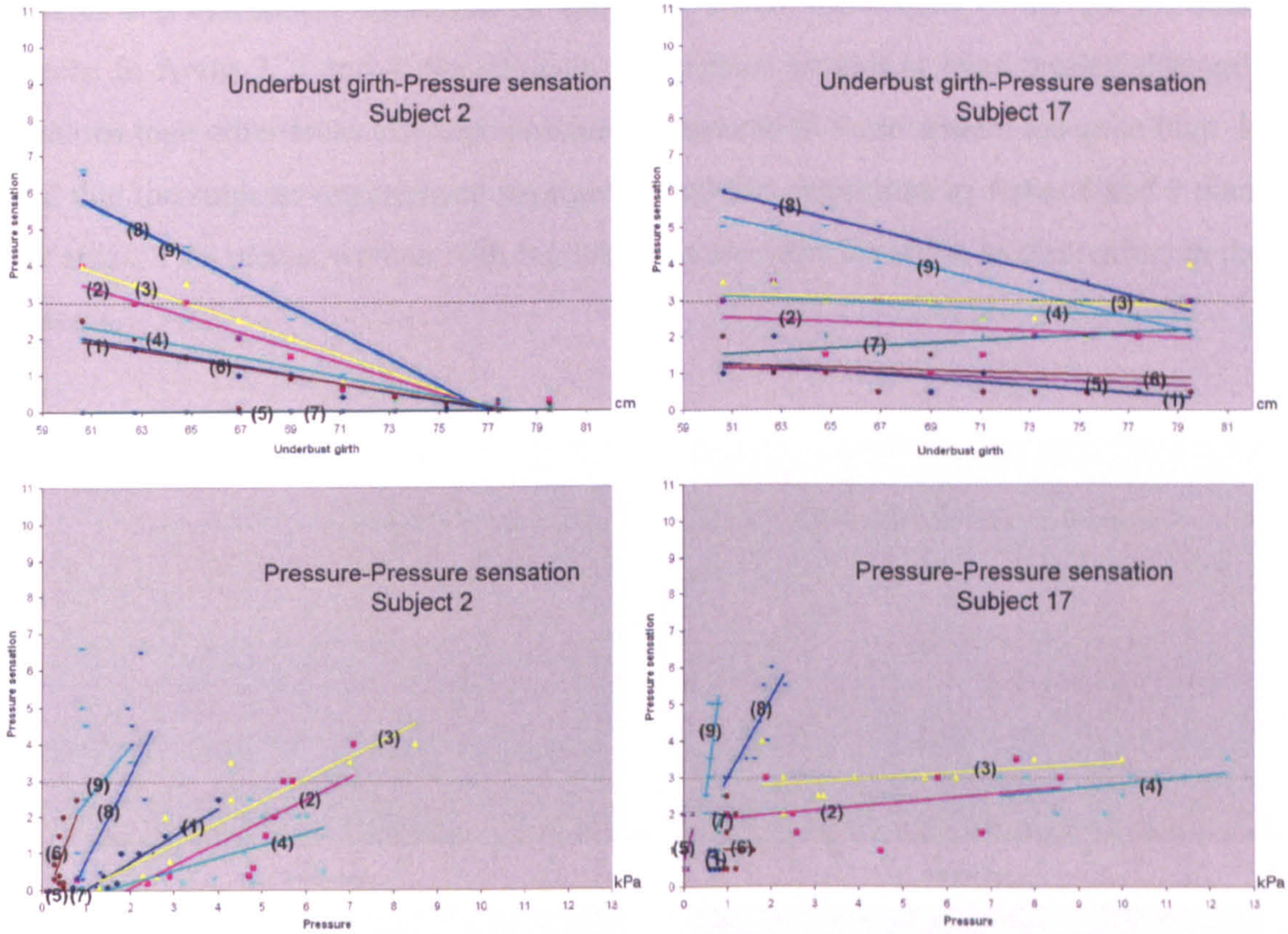


Figure 6.16 Underbust girth, Pressure-Pressure Sensation for Subjects 2 and 17 in group 10

Using the reference lines in Figure 6.16, in order to keep the pressure sensations in most of the nine focal areas are not more than moderate, the underbust girth should not be less than 69cm for Subject 2 and 78cm for Subject 17. Therefore, very different results could be found for these two subjects although their calculated bra sizes are the same. The commercial underbust girth for a 36 underband bra is 77cm, therefore a size 36 is not tight for Subjects 2 and 17. But these subjects tend to wear size 34 underband bras normally, which should be satisfactory for Subject 2, but it would be more advisable for Subject 17 to wear a size 36 bra.

The relationships between the underbust girth and discomfort sensations, and pressures and discomfort sensations are shown in Figure 6.17. There are negative correlations between the underbust girth and the discomfort sensations, and positive correlations between

pressures and discomfort sensations in most of the nine focal areas of the bra for these 2 subjects. In Areas 2, 3 and 4, the subjects experienced similar or even weaker discomfort sensations than other areas although pressures measured in these arrears are quite high. It is found that the subjects experienced stronger discomfort sensations in Areas 8 and 9 than in other areas. This means women with big bra sizes are more sensitive to discomfort in these two areas.

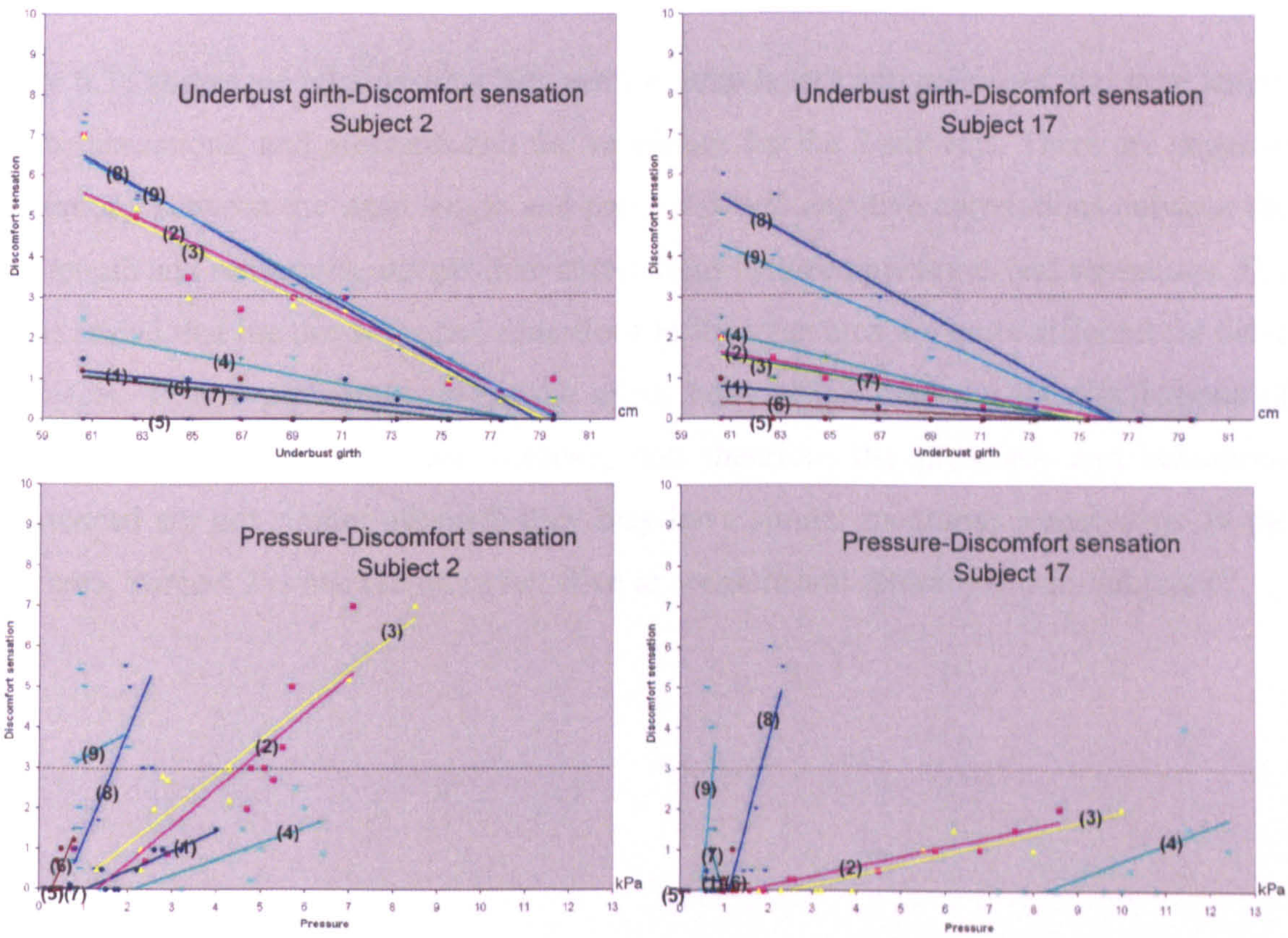


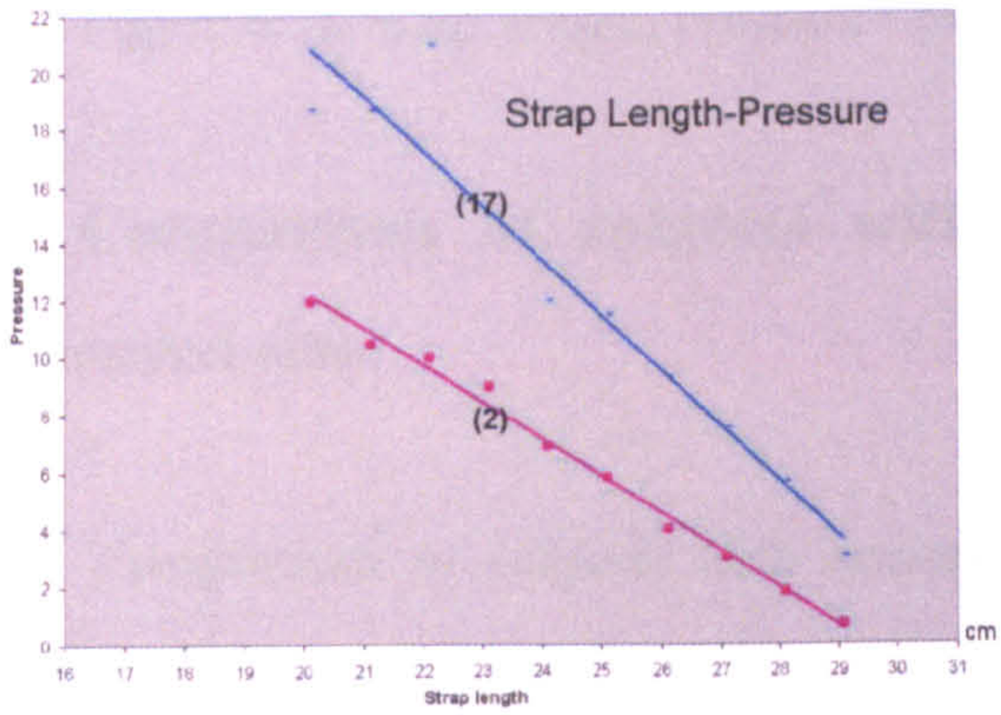
Figure 6.17 Underbust girth, Pressure-Discomfort sensation for Subjects 2 and 17 in Group 10

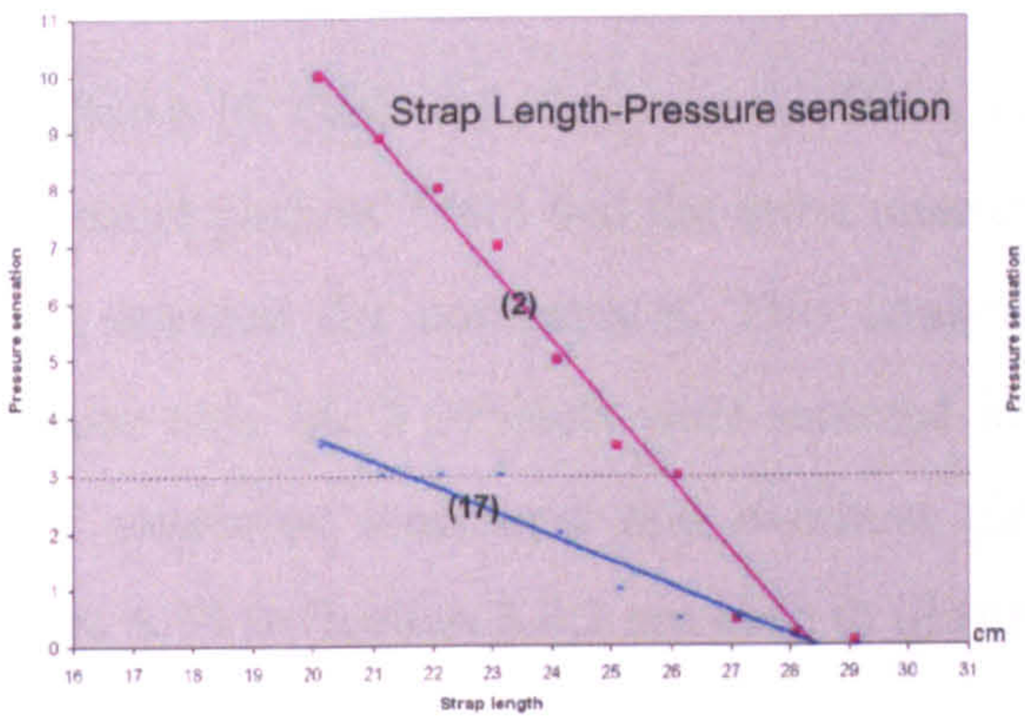
Using the reference lines for 'moderate' in Figure 6.17, so that the discomfort sensations in all nine focal areas do not exceed 'moderate', the underbust girth should not be less than 71cm for Subject 2 and not less than 68cm for Subject 17. The commercial underbust girth is 77cm for a size 36 underband bra, and therefore the bra size of 36 does not cause any

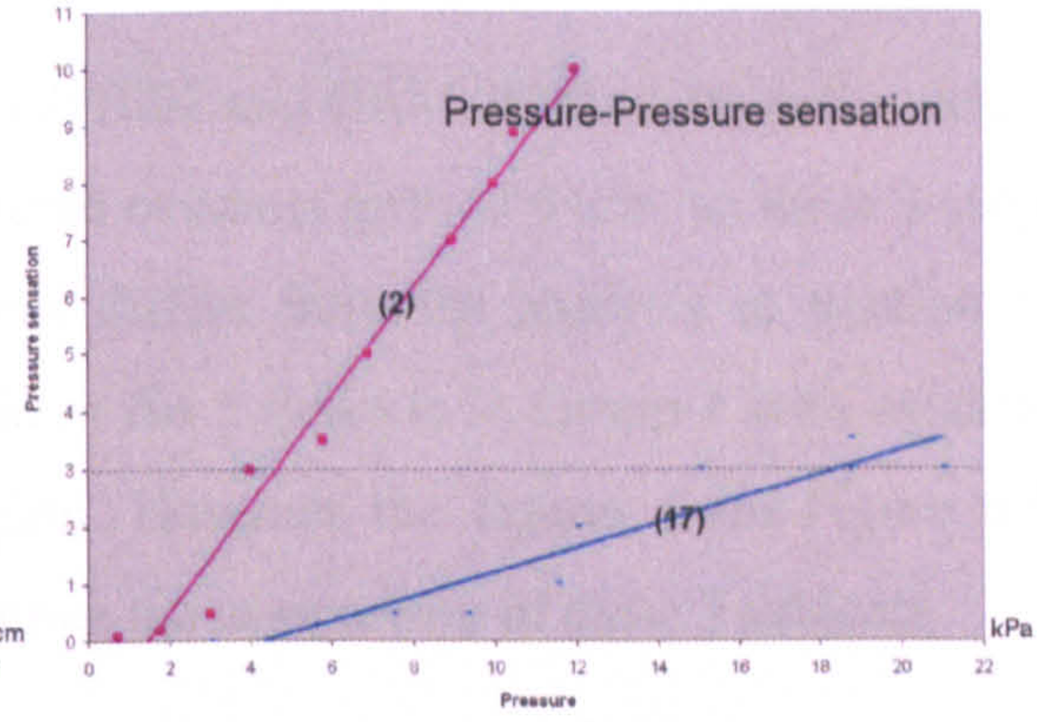
problems for Subjects 2 and 17. These two subjects tend to wear 34 underband bras normally, so that if only discomfort sensations are considered, a size 34 underband bra should be suitable.

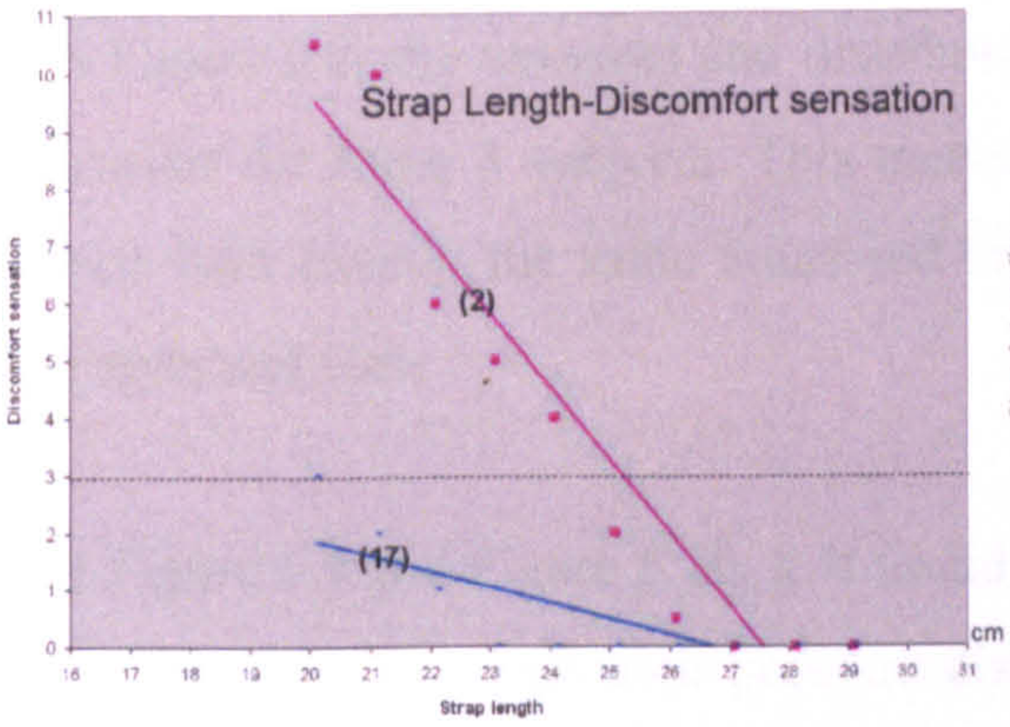
For Subjects 2 and 17, the pain sensations for all the different underbust girths do not exceed moderate; this means that the pain sensation is not great enough to cause any problems to the wearers, therefore the pain sensations will not be considered here.

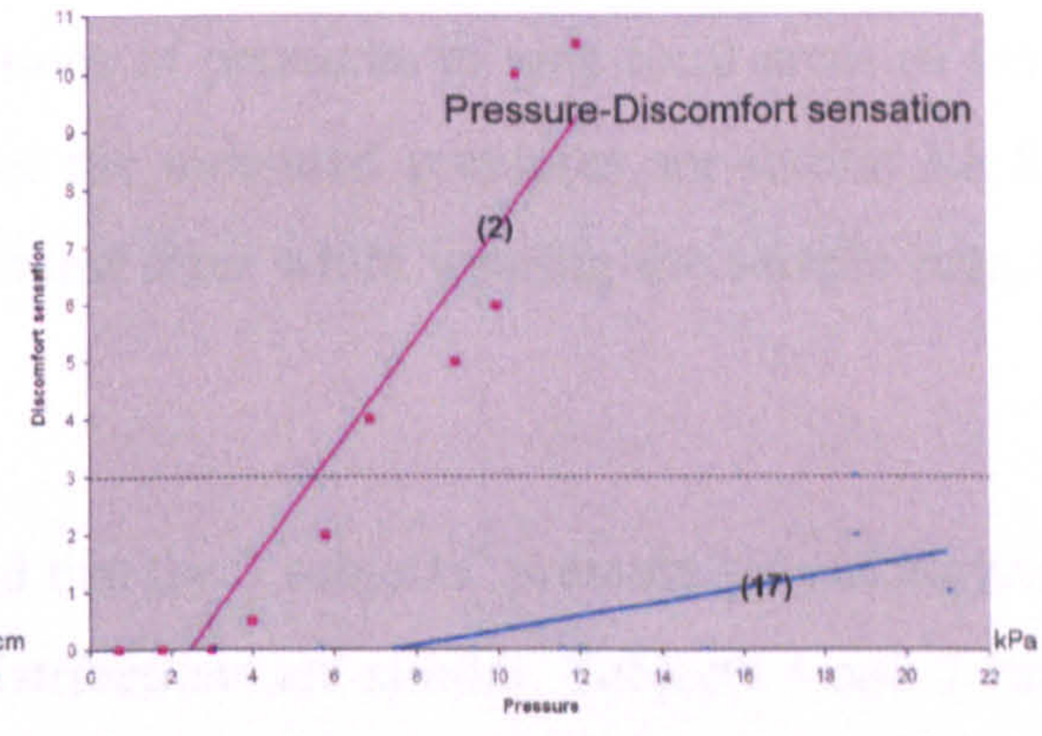
Figure 6.18 shows the relationships between the strap length and pressures, the strap length and the sensations, and pressures and the sensations for the 2 subjects. There are negative correlations between the strap length and pressures, and negative correlations between the strap length and sensations, but positive correlations between pressures and sensations. The graphs reveal that the pressures and sensations in the strap area are quite different for these 2 subjects. This is probably because the upper body shapes and the fat distributions of women with large bra sizes are variable, and therefore the pressures and sensations experienced are not similar although they may have similar measured breast sizes. In the strap area, Subject 2 is marked more sensitive to pressure and sensations than Subject 17.

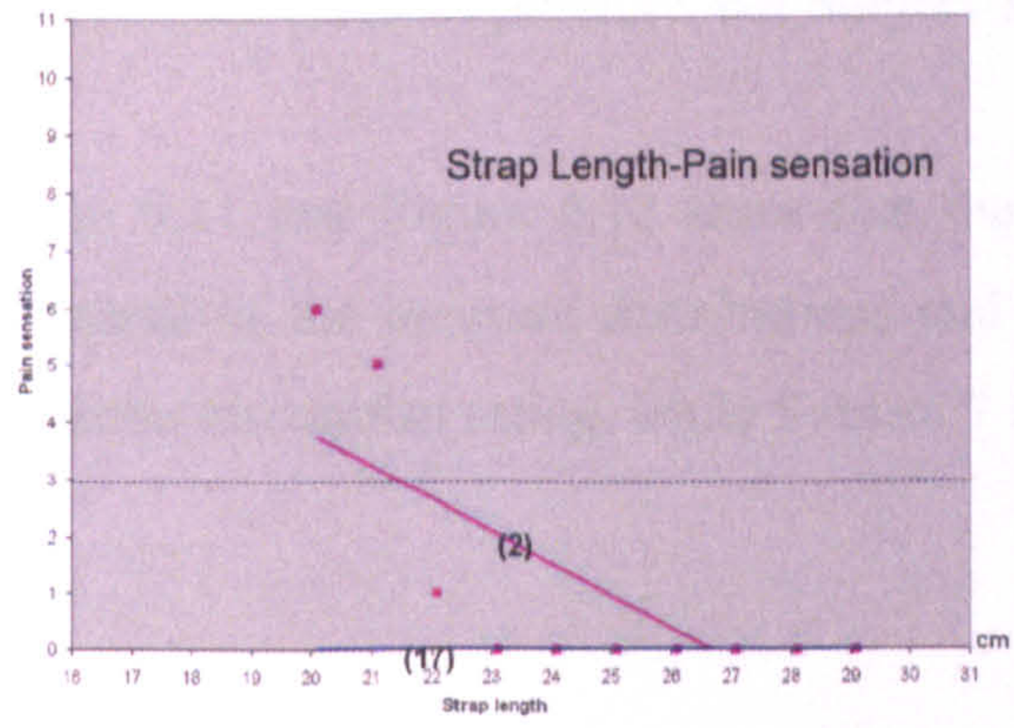

Strap Length-Pressure
(17)
(2)
Pressure
Strap length
cm


Strap Length-Pressure sensation
(2)
(17)
Pressure sensation
Strap length
cm


Pressure-Pressure sensation
(2)
(17)
Pressure sensation
Pressure
kPa


Strap Length-Discomfort sensation
(2)
(17)
Discomfort sensation
Strap length
cm


Pressure-Discomfort sensation
(2)
(17)
Discomfort sensation
Pressure
kPa


Strap Length-Pain sensation
(2)
(17)
Pain sensation
Strap length
cm

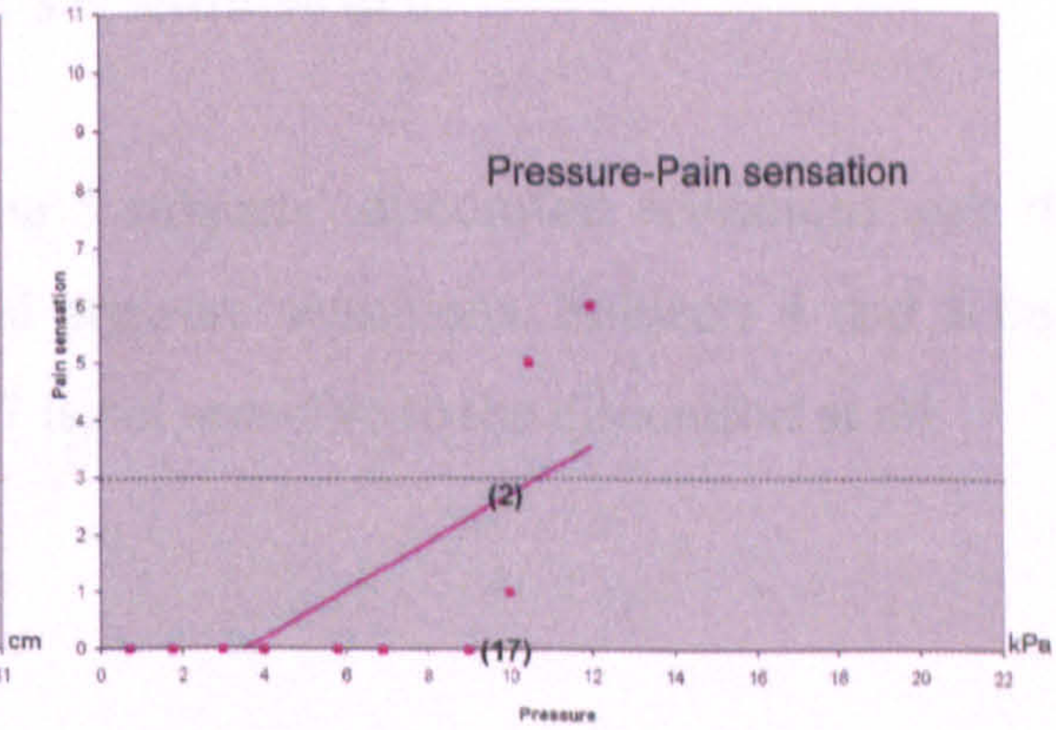

Pressure-Pain sensation
(2)
(17)
Pain sensation
Pressure
kPa

Figure 6.18 Strap length, Pressure - Sensations for Subjects 2 and 17 in Group 10

6.5 Comparison of subjects with similar measured size or different measured size

6.5.1 Comparison of subjects with exactly the same measured underbust and overbust girth

As shown in Table 6.6, Subjects GRT004, GRT007 and GRT008 have the same measured underbust girth of 72cm and the same measured overbust girth of 84cm, so these 3 subjects were selected for comparison. This analysis differs from the analysis in Section 6.4.1 because only the 3 subjects were selected from the 5 subjects in Group 1 with exactly the same measured underbust and overbust girth. However the figures from Figure 6.8 to Figure 6.14 in Section 6.4.1 are used to illustrate the comparison of these 3 subjects.

From Figure 6.8, the amounts and distributions of pressures in nine focal areas of the bra are similar for these 3 subjects. This means the measured pressures are similar for these subjects with exactly the same measured breast sizes while wearing the sample bras with same style and size.

From Figure 6.9 and Figure 6.10, it is found that the 3 subjects' pressure sensations are not always the same although their pressure distributions are similar. Subjects 4 and 7 have a moderate sensation of pressure, but Subject 8 is sensitive to it.

Figure 6.11 and Figure 6.12 show that the 3 subjects' discomfort sensations also differ compared to the pressure distributions and pressure sensations. Subjects 4 and 8 have a moderate discomfort rating, while Subject 7 is not sensitive to the discomfort at all.

Pain sensations are not discussed because for all the 3 subjects, pain sensations do not exceed the moderate rating.

From Figure 6.13 and Figure 6.14, it is discovered the pressure distributions in the strap areas are different and the pressures, discomfort and pain sensations experienced by the 3 subjects also differ. Although these three subjects have exactly the same measured breast sizes, it does not mean that their body shapes above the breasts are also similar. The pressure and sensations in the strap area will also be influenced by the shapes of the shoulder, and therefore, more factors should be considered when investigating the pressure and sensations in the strap area.

By comparing subjects with exactly the same measured underbust and overbust girth, it is discovered the pressure distributions in the different areas of the bra are similar for these 3 subjects, but their sensations of pressure, discomfort and pain are not always the same. It means different subjects have their own different sensitivities thresholds for the pressure, discomfort and pain, even though they have exactly the same size of busts.

6.5.2 Comparison of subjects with same measured underbust girth but different overbust girth

As shown in Table 6.6, Subject GRT014, GRT015 and GRT018 have the same measured underbust girth of 78cm, but different overbust girths, GRT014 is 89cm, GRT015 is 94cm and GRT018 is 99cm. These 3 subjects were selected for comparison.

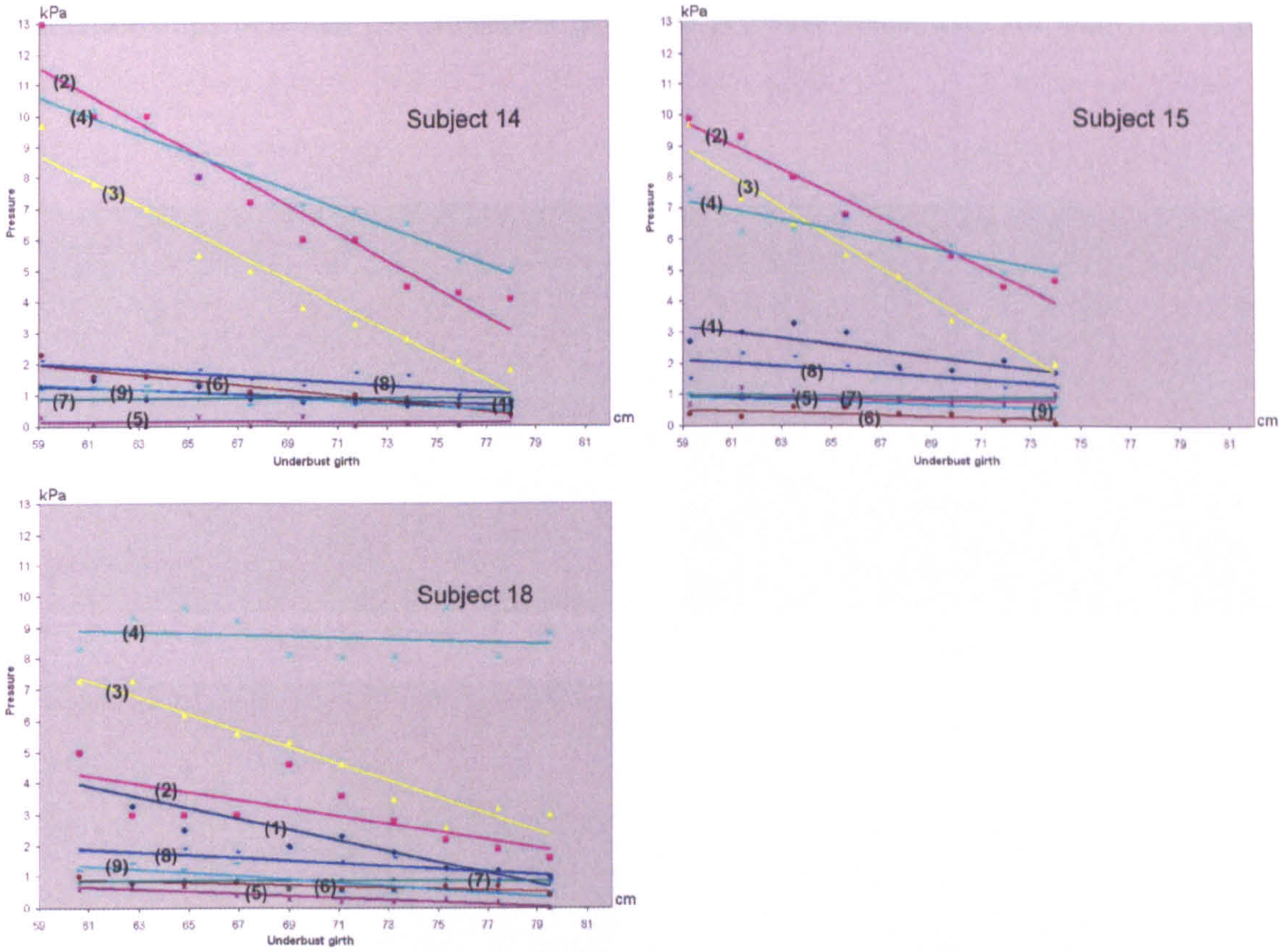


Figure 6.19 Underbust girth – Pressure of Subjects 14, 15 and 18

Figure 6.19 shows the relationships between the underbust girth and pressures of these 3 subjects. It reveals that the pressure distributions are similar for these three subjects although their overbust girths are different. It should be noted that for Subject 18, the data shows that there is a difference in that the pressure in Area 2 is not so high in comparison to other two subjects. This again proves that the characteristics of pressure and sensations are more complicated for women with large bra sizes compared to these who take smaller sizes.

The relationships between the underbust girth and pressure sensations are shown in Figure 6.20.

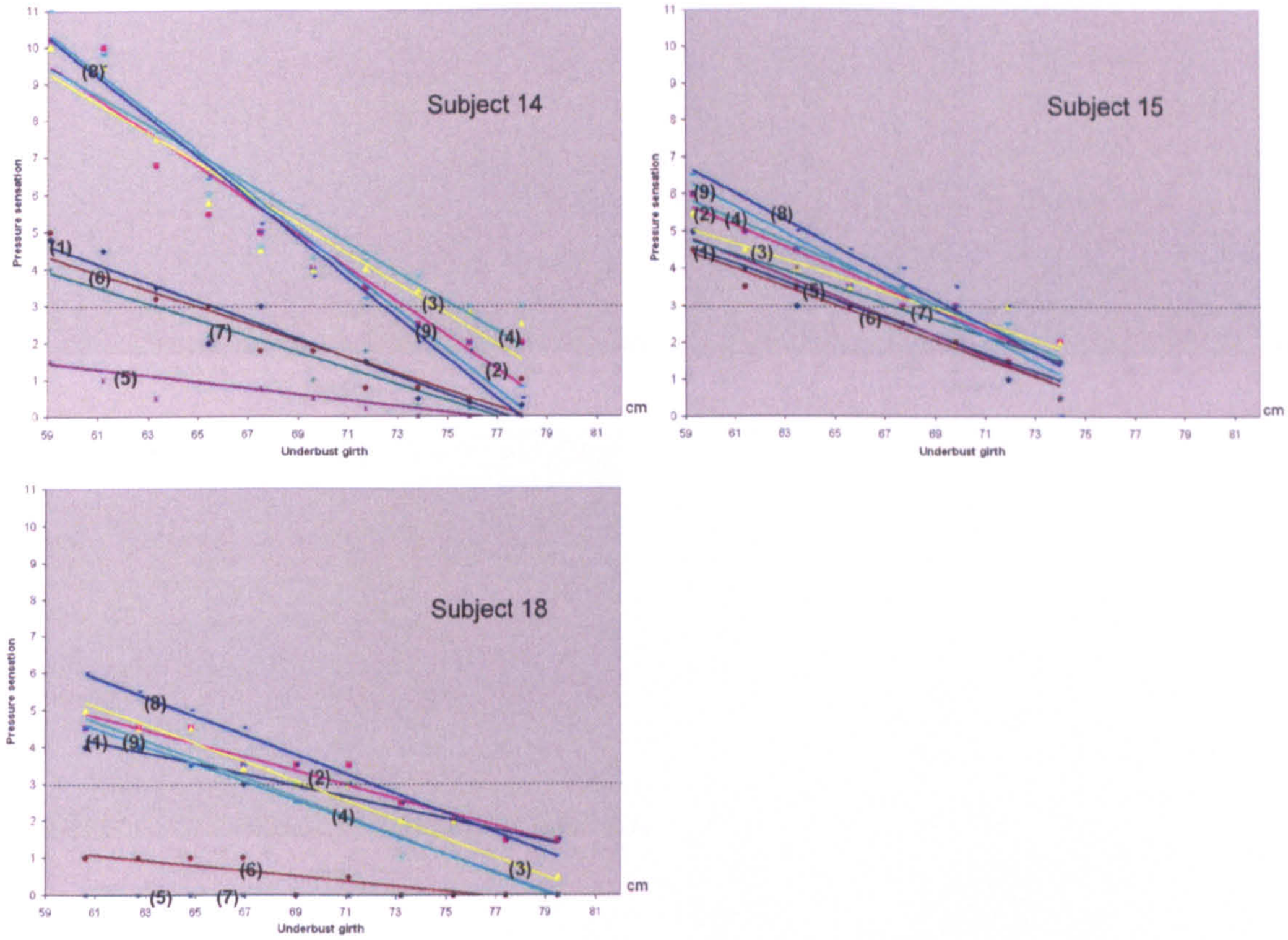


Figure 6.20 Underbust girth – Pressure sensation of Subjects 14, 15 and 18

The relationships between pressures and pressure sensations are shown in Figure 6.21.

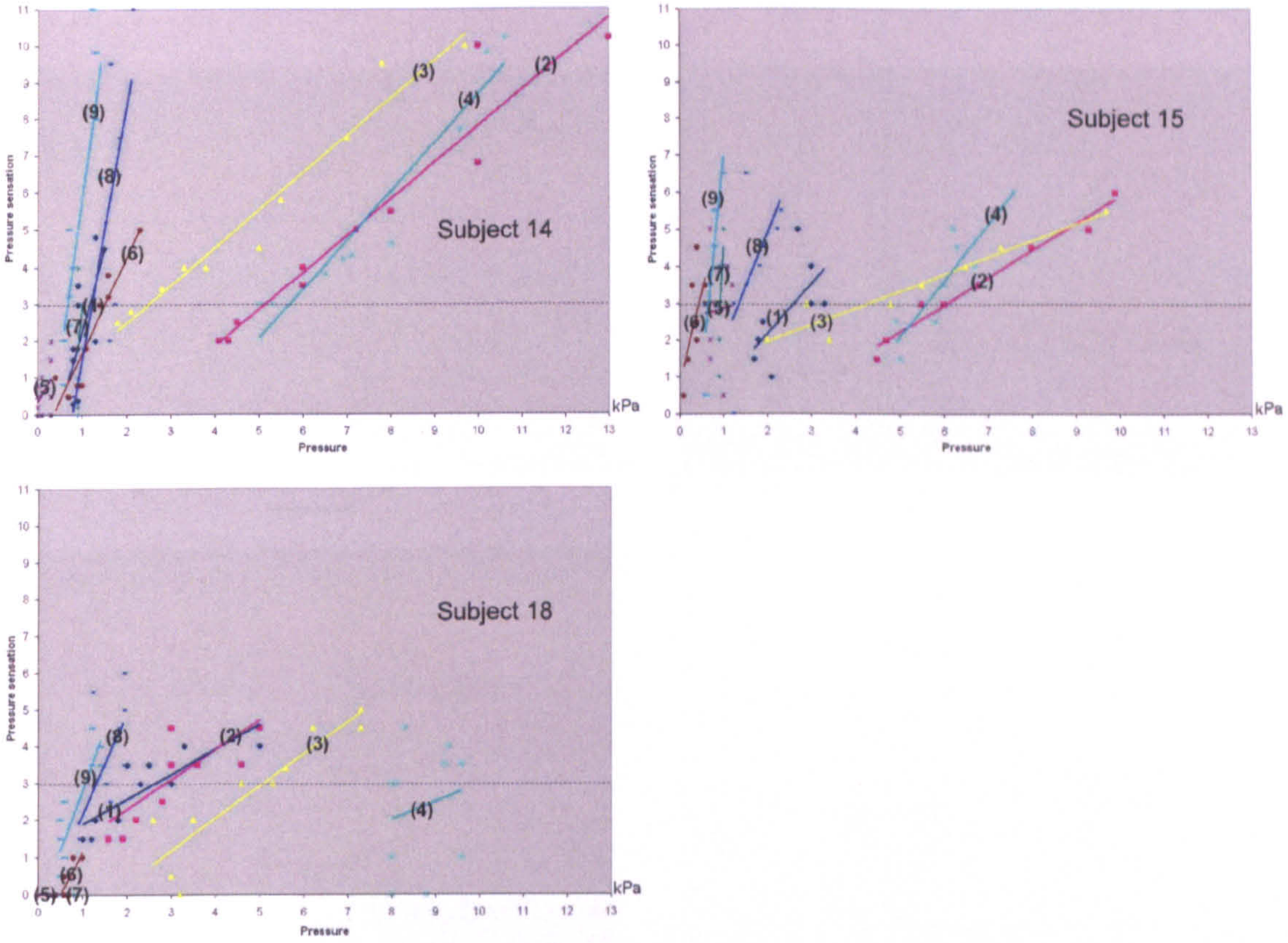


Figure 6.21 Pressure – Pressure sensation of Subjects 14, 15 and 18

It is discovered that the 3 subjects' pressure sensations are completely different although their pressure distributions are similar. It seems that there is a tendency that women with big bra cup size tend to tolerate more pressure than women with small cup size; this means that women with big bra sizes tend to be less pressure sensitive than women with small bra sizes.

The relationships between the underbust girth and discomfort sensations are shown in Figure 6.22.

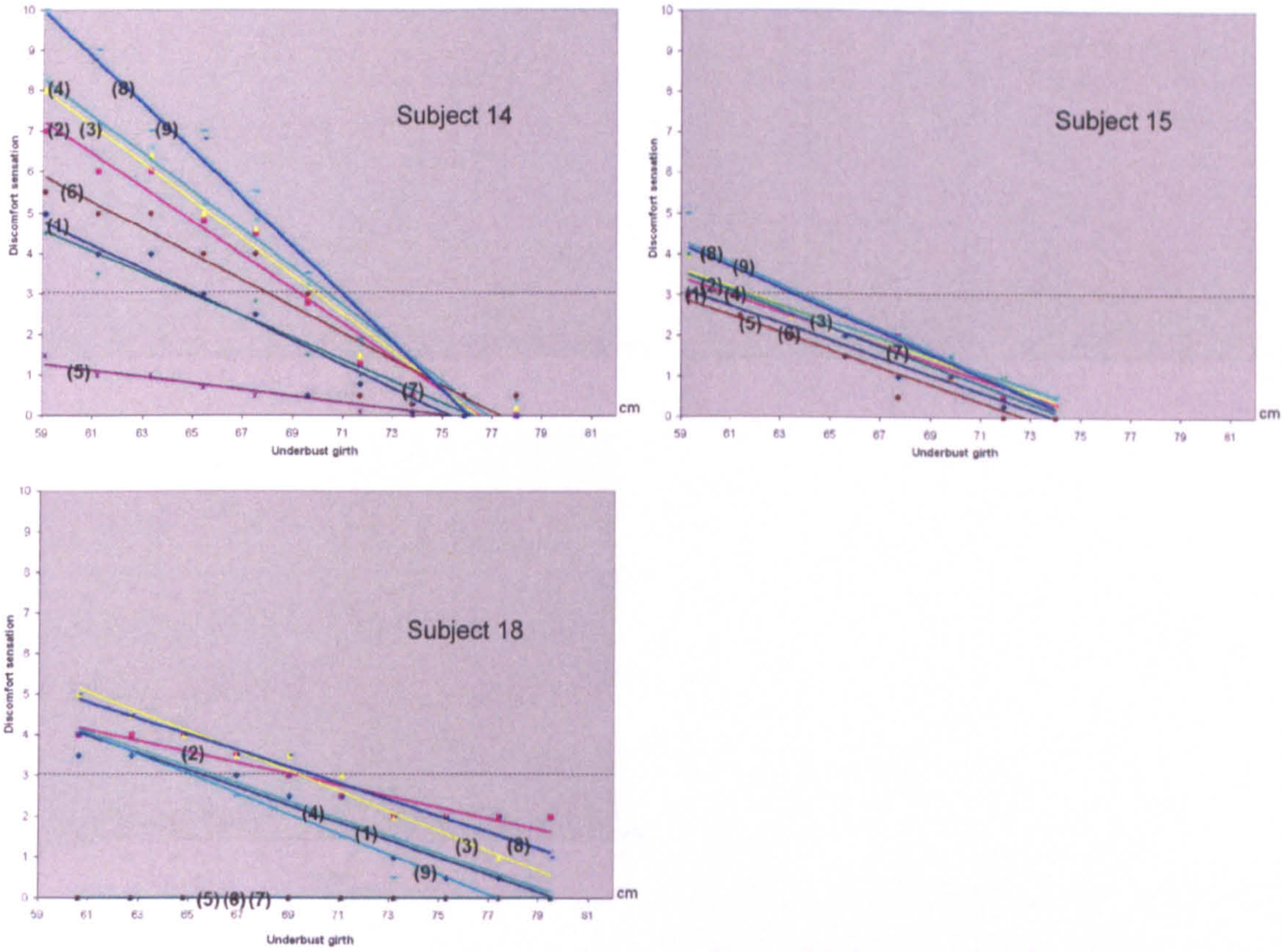


Figure 6.22 Underbust girth – Discomfort sensation of Subjects 14, 15 and 18

The relationships between pressures and discomfort sensations are shown in Figure 6.23.

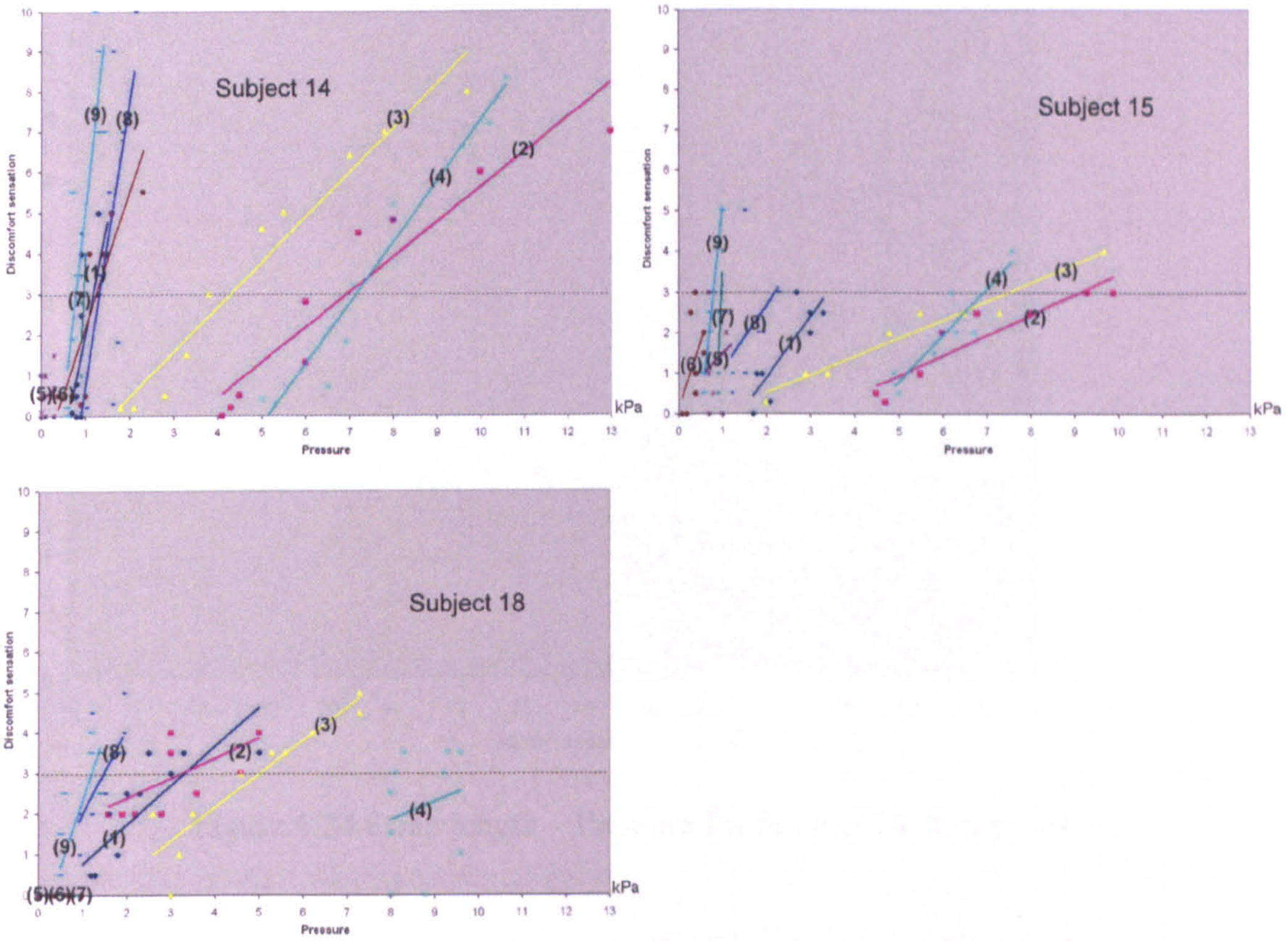


Figure 6.23 Pressure – Discomfort sensation of Subjects 14, 15 and 18

It is discovered the 3 subjects' discomfort sensations are totally at variance although their pressure distributions are similar. This also means that women with big bra sizes tend to be less sensitive to discomfort than women with small bra sizes.

The pain sensations are not discussed because pain sensations do not exceed the moderate sensation for all the 3 subjects.

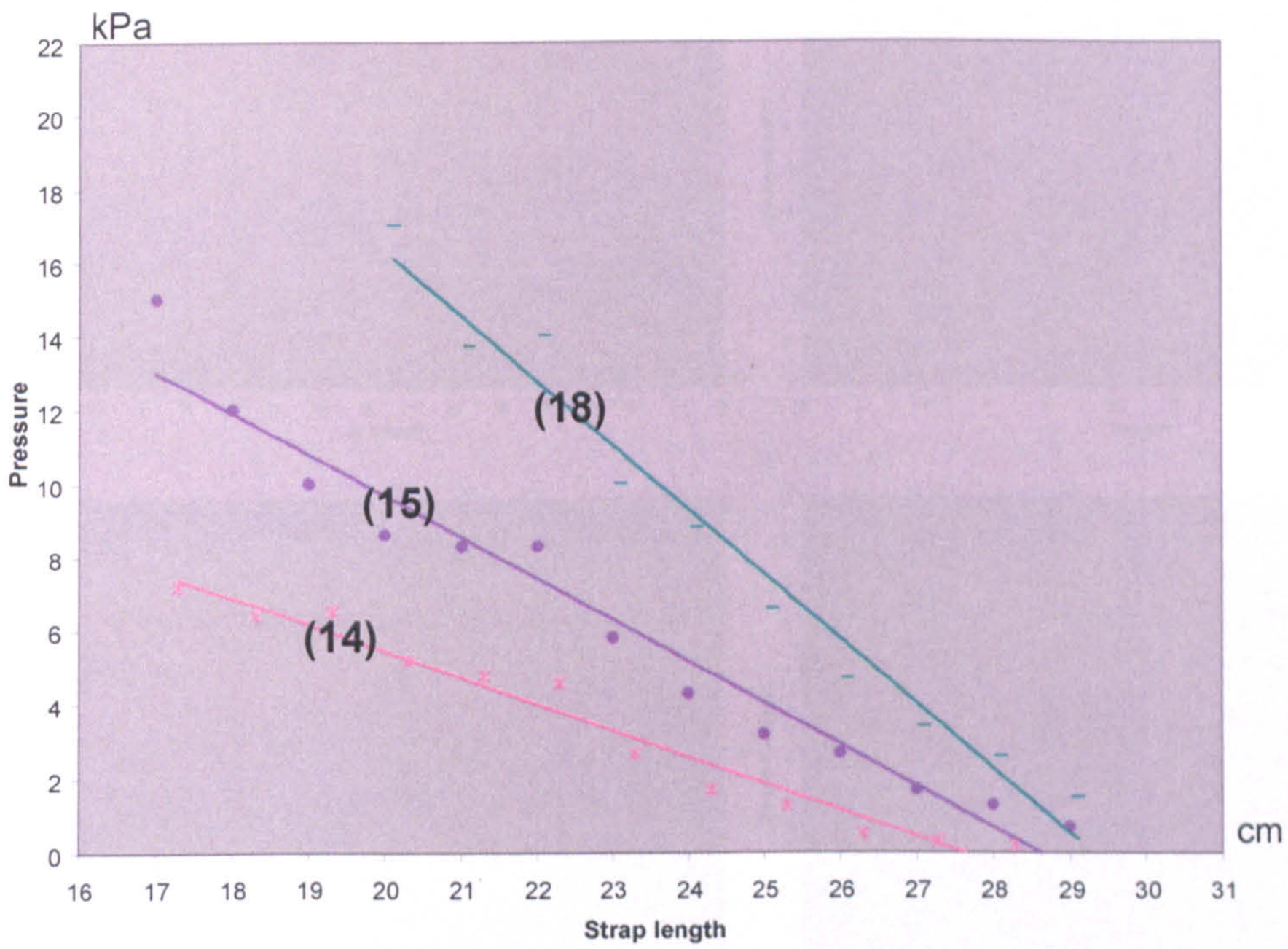
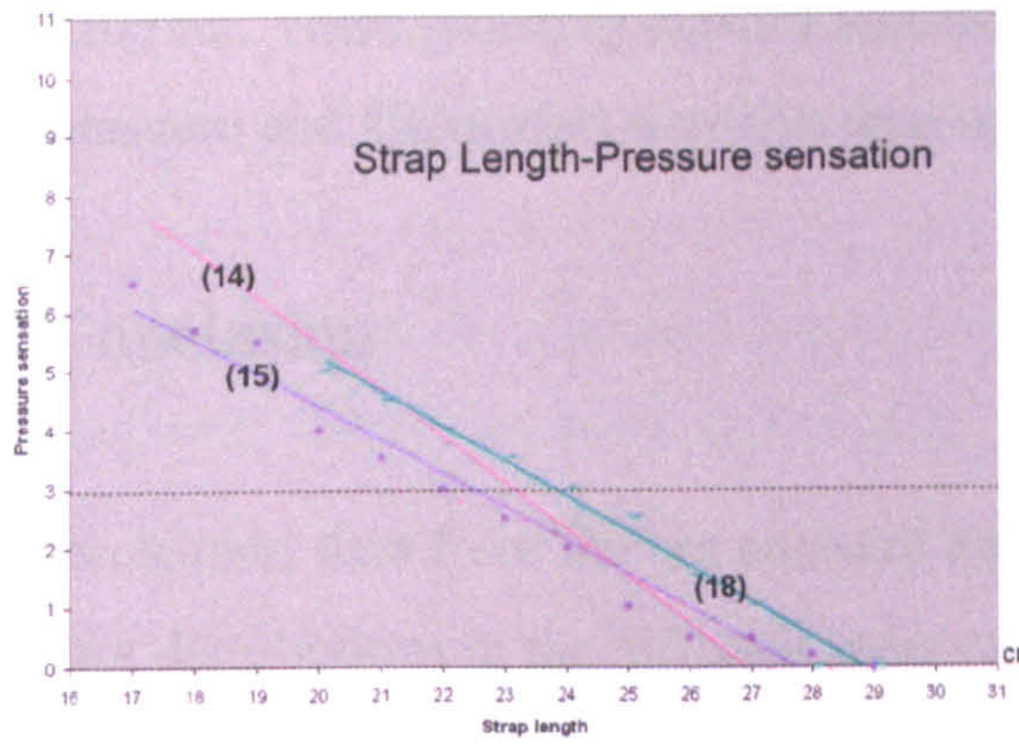
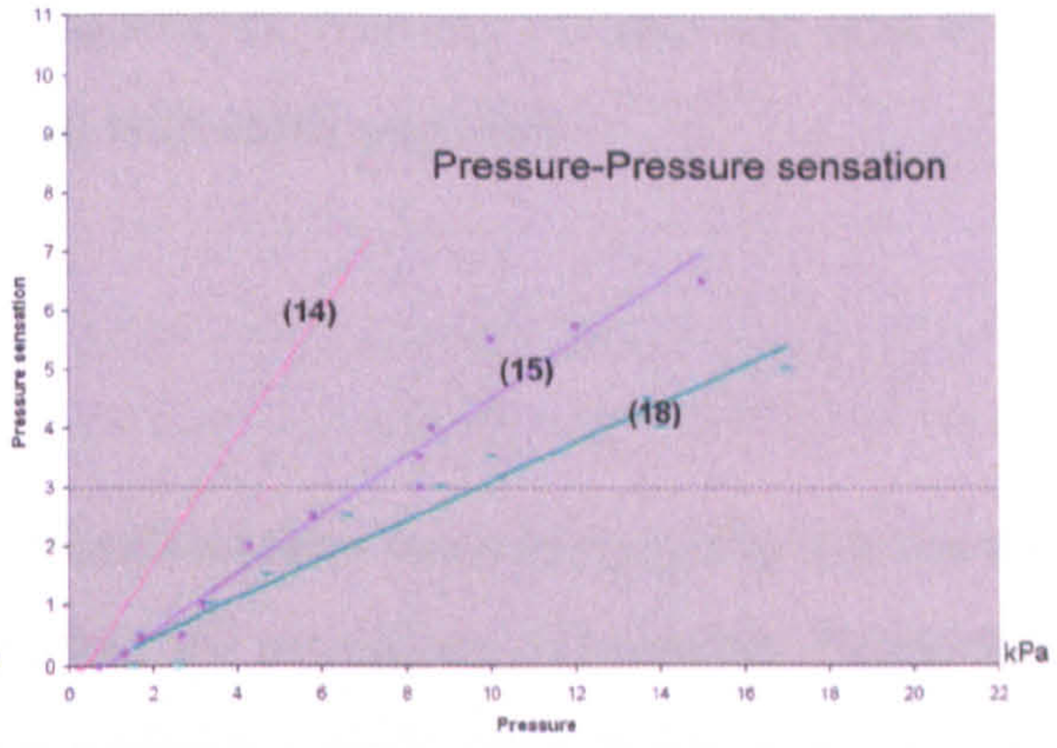
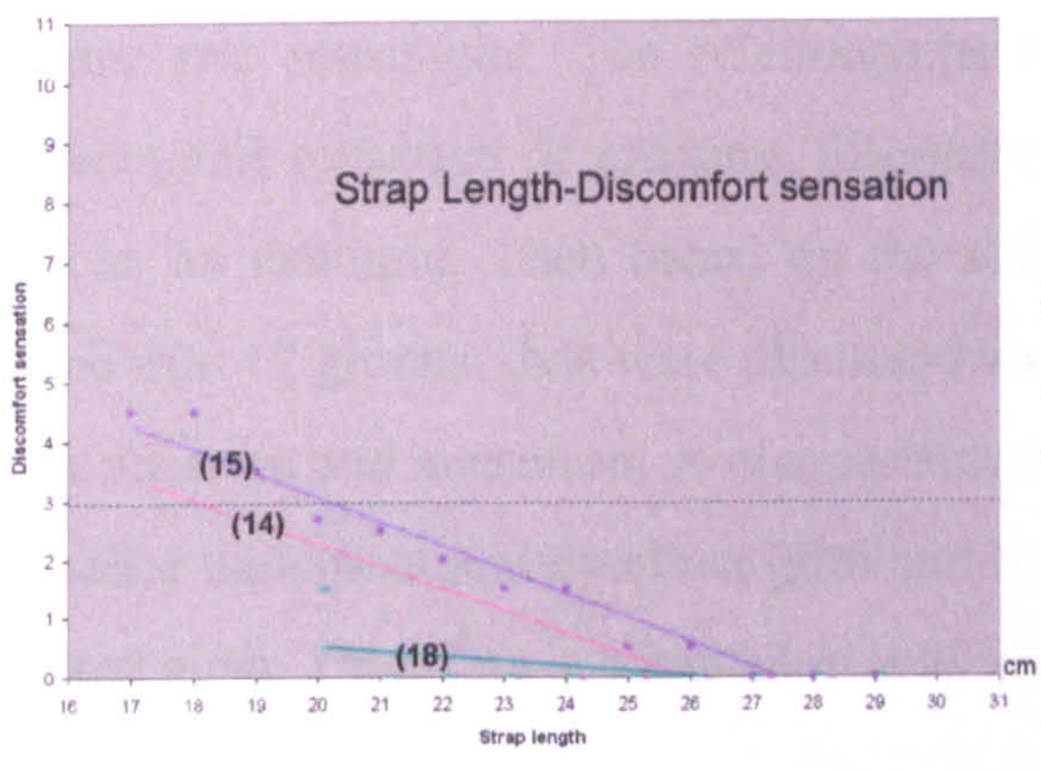


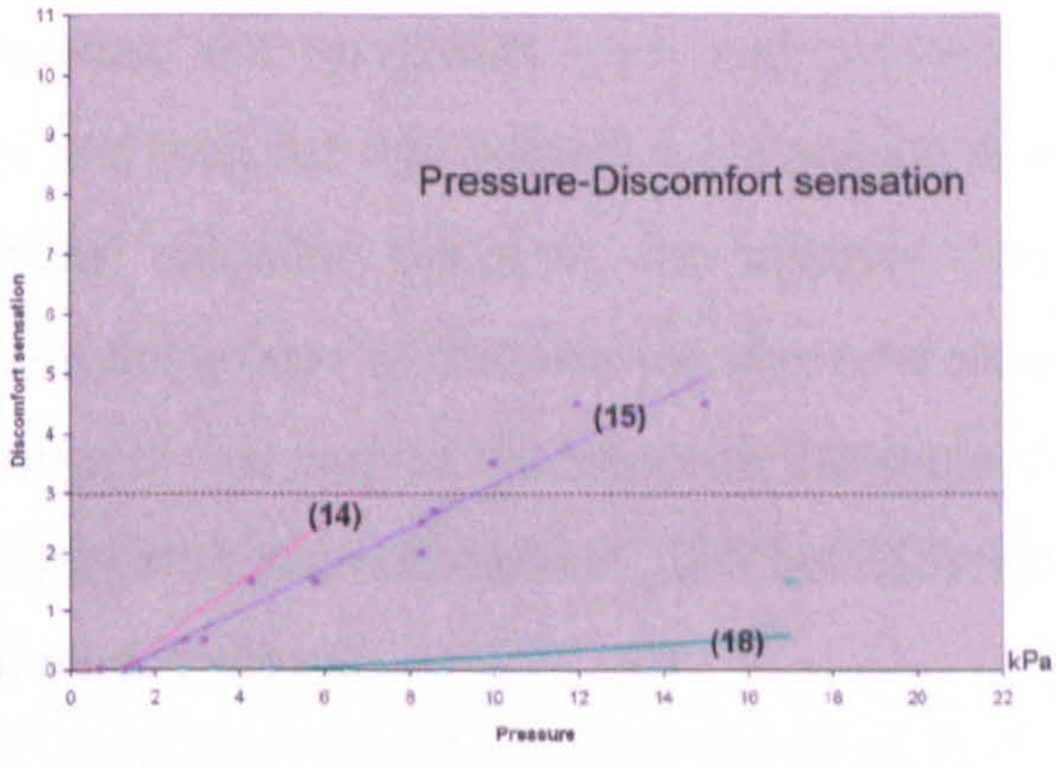
Figure 6.24 Strap length – Pressure for Subject 14, 15 and 18

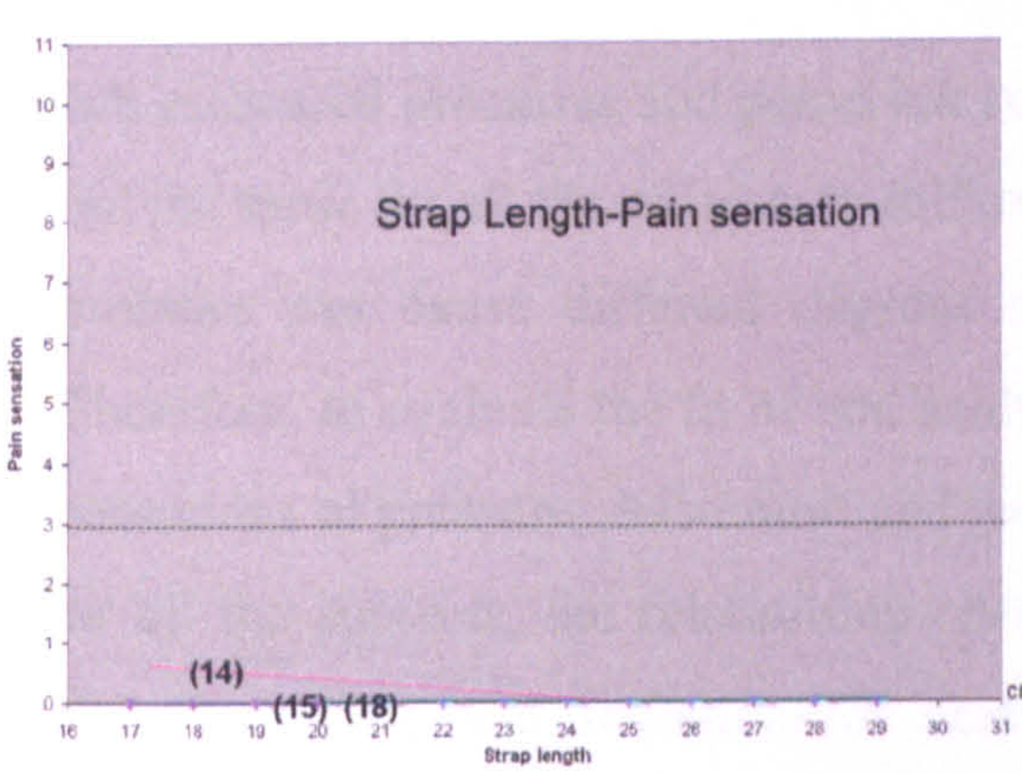
Figure 6.24 shows the relationships between the strap length and pressures. Figure 6.25 shows the relationships between the strap length and sensations, pressures and sensations. It is discovered the pressure distributions in the strap areas are different and their pressure, discomfort and pain sensations are also different for the 3 subjects. This is because the pressure and the sensations of the strap areas are probably influenced by the shape of the shoulder, therefore, more factors should be considered while investigating the pressure and sensations in the strap area.











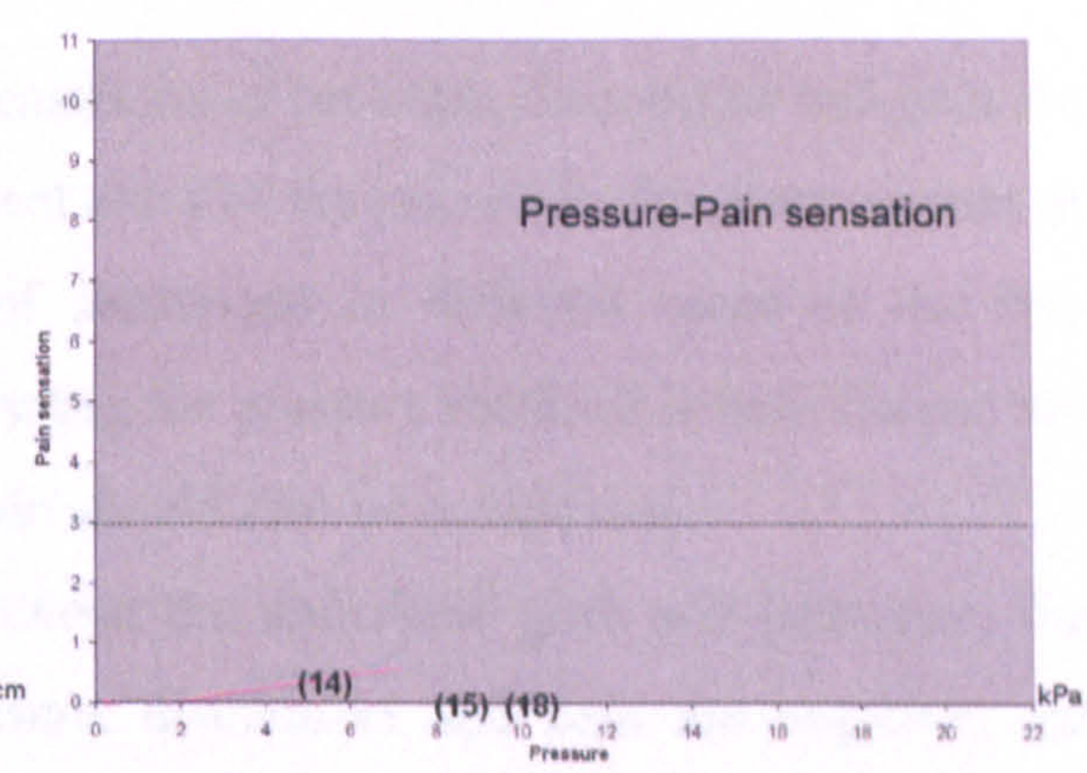


Figure 6.25 Strap length, Pressure – Sensations for Subjects 14, 15 and 18

By comparing subjects with exactly the same measured underbust girth, but different overbust girth, it is discovered the pressure distributions measured in the different areas of the bra are similar for the 3 subjects, but their sensations of pressure, discomfort and pain

are different. There probably exists a tendency that women with big bra cup size tend to be less pressure and discomfort sensitive than women with small cup size.

6.6 Conclusion

In this chapter, data from the bra pressure and sensations tests were analyzed to discuss the pressure distributions in the different areas of the bra, the sensations of pressure, discomfort and pain caused by wearing the bra, and how the underbust girth, strap length influence the pressure and sensations. The relationships between the underbust girth and pressures, pressures and sensation of pressure, discomfort and pain for one subject were analyzed in detail as an example. Then based on the subjects' calculate bra sizes, the subjects were divided into 12 groups, data were discussed within the groups to discover the characteristics of the pressure and sensation. A comparison analysis was carried out between the subjects with same underbust and overbust girth and subject with same underbust girth but different overbust girth. Therefore, a conclusion is as shown as follows:

(1) Both measured pressures and perceived sensations of pressure, discomfort and pain are not the same for all the subjects in different areas of the bra. Also, the same amount of pressure can cause different degrees of sensations in different areas of the bra. Therefore, to evaluate the fit of bra, analyzing the pressure readings is insufficient; the sensations of pressure, discomfort and pain should also be considered.

(2) For all the subjects, the relationships between the underbust girth and pressures, the underbust girth and sensations of pressure, discomfort and pain are negative, the relationships between pressures and sensations of pressure, discomfort and pain are positive. But there are two exceptions, which are Subjects 3 and 12, the relationships between the underbust girth and discomfort sensations are positive, the relationships between pressure and discomfort sensations are negative. This means these two subjects have different sensations comparing to other subjects, what they probably think the tighter, and the more comfortable.

(3) For most subjects, the highest pressure was experienced in the underband and underwire areas of the bra, relatively weaker pressures are experienced in the upper part of the bra, the bra cup and the centre back. The strongest sensations of pressure were experienced in the underband, underwire and the back areas of the bra; the weakest pressure sensations were experienced in the high point of the bust. The strongest sensations of discomfort were experienced in the back areas of the bra; the weakest discomfort sensation was experienced in the high point of the bust. There are only a little pain sensations in the underband, underwire and the back areas of the bra, no pain sensations in other areas at all. It seems that wearers can stand more pressures in the underband and underwire areas comparing to other areas.

(4) For most subjects, the area of bra back seems to be a specially sensitive area, subjects perceive stronger sensations of pressure, discomfort and pain although the measured pressures are not high in this area. There is a dramatic increase in the degree of the sensations as the underbust girth of the bra decreases. This means when the underband of the bra is quite loose, the measured pressures are quite light and the perceived sensations are quite weak, but the perceived sensations will increase a lot while the underband of the bra is changed to a very tight size although the measure pressures will not increase too much. Therefore, the bra back area should be especially considered in bra fitting and design.

(5) For all the subjects in the strap area, the relationships between the strap length and pressures, sensations of pressure, discomfort and pain are negative, the relationships between pressures and sensations of pressure, discomfort and pain are positive. There are not many differences among the subjects for the increases of pressure and sensations along with the increases of the strap lengths. The ideal strap length for every subject is different due to the different upper body shape and the fat distribution.

(6) By comparing subjects with small and large calculated bra size, it was discovered that the measured pressure values in different areas of the bra are similar for smaller sized subjects with similar calculated bra size. In contrast, the measured pressure values in different areas of the bra very considerably for larger sized subjects with similar calculated bra size. It is probably because the smaller sized women do not have too

much fat in their upper body, therefore the upper body shape and the softness of skin are quite similar, then the pressure caused by wearing the bra are also similar. But the larger sized women have more fat in their upper body, the distributions of the fat in the body are not the same, therefore pressures are also not the same.

(7) By comparing subjects with exactly the same measured underbust and overbust girth, it was discovered that their pressure distribution in the bra is similar, but the reported sensations of pressure, discomfort and pain are not always the same. These means that different subjects have their own unique sensitivities to pressure, discomfort and pain. Similarly, by comparing subjects with exactly the same measured underbust girth, but different overbust girth, it was discovered that their pressure distributions in the bra is similar, but the reported sensations of pressure, discomfort and pain differ. There is some suggestion in the data that women who need larger cup sizes tend to tolerate more pressure and discomfort than those who take smaller cup.

(8) For larger sized women, the back area is more sensitive to pressure than other areas comparing to smaller sized women. It is quite hard to achieve a satisfied sensation for this area. Therefore the back area of the bra should be especially considered in the bra design process.

(9) Examining the data for the underbust girth of the bra, the correct underbust girth is similar for smaller sized subjects with similar calculated bra size, but it varies considerably for the larger sized subjects with similar calculate breast size.

(10) Comparing the data of sensations from the survey and from tests, revealed that for smaller sized subjects, these two groups of data are, to some extent, similar in amount and characteristics. The data from the survey are probably enough to analyse the characteristics of the pressure and sensations caused by wearing a bra. But for larger sized women, there is too much disparity within these two groups of data. In general, the data from the survey are more generous, and reflect an overall perception of sensations to any styles of bras which wearers have ever worn. But data from pressure and sensation tests are more specialized, and reflect the perception of sensations at a specific moment for a specific style of the bra; the data can be used to investigate the perfect fit for this style of the bra.

(11) From above, it may be concluded that a general correct pressure distribution in different areas of the bra can be established to achieve a good fit for smaller sized women with similar breast size, a correct underbust girth can also be designed for the these groups of women. However it is more difficult achieve this for larger sized women, which is why larger sized women find it is difficult to obtain perfectly fitting bra when shopping. Due to the diversity in body shape and fat distributions in the breast area and the upper body shape of larger sized women, it is not easy for them to achieve a good fit for the bra using the same sizing system as that applicable to smaller sized women. An individual analysis of their shape and problems of fitting is more appropriate in these cases.

Chapter Seven
Conclusion and future work

7.1 Conclusions

There are still many women who are not satisfied with the bra they are wearing and finding difficulty to obtain a satisfactory fit, especially in the case of large-sized women. Previous research has shown that pressure is a very important factor in bra fitting, as is the wearer's perception of the comfort of the bra, these having a direct bearing on issues of breast health. The whole field of the fitting of bras requires more scientific and technical research.

With increasingly concerns of the issues arising from bra fitting, this scientific research has investigated the pressure and sensations caused by wearing a bra and their influence on bra fitting issues. The extensive survey and assessment of pressure and sensations were carried out to discover the relationships amongst the bra wearer's wearing habits, pressure, and perceptible sensations.

It was found that different subjects have their own unique sensitivities to pressure, discomfort and pain due to their bra wearing. The comparison of subjects with exactly the same measured underbust girth, but different overbust girth revealed that their pressure distributions in the bra are similar, but the perceptible sensations of pressure, discomfort and pain could differ. From the pressure measurements and their assessments of the sensations, it was shown that there are no two subjects having the same pressure and

sensation, especially for the large-sized women. Furthermore the same amount of pressure can cause different degrees of sensation in different areas of the bra. Therefore, only relying on appearance or analysing the pressure readings is not sufficient to judge the fit of a bra. The sensations of pressure, discomfort and pain perceived by the subjects should also be considered. The general characteristics of wearers' sensations in the bra and the relationship between the pressures and the sensations can be directly used by designers to improve designs and reduce iterations of the trail and error.

This research work from the extensive survey, assessment of pressure and sensations due to wearing a bra and data analysis have generated the extensive knowledge of wearers' habits and the relationship between the pressures and the sensations. Major outcomes and conclusions are summarized below.

(1) The areas most difficult to fit of a bra are the centre neck edge and the upper underarm. Bigger sized women prefer full support for their breasts, whilst smaller sized women prefer medium or light support for their breasts. However, women who need larger cup sizes tend to tolerate more pressure and discomfort than those who require smaller cups. Therefore breast support is the most important factor for heavier and bigger cup sized women.

2) Wearers' bra wearing characteristics have some correlations with their age, body shape and bra styles. Different fitting problems exist in different areas of the bra. For example, older women think the centre underband of the bra is hard to fit, but the centre neck edge is probably easy to fit. Women who need a larger back size find that the centre front is relatively easy to fit, but the centre back is quite hard to fit. Those who need a bigger cup size find that the centre front and the upper underarm are difficult to fit, but the high point of the bust is quite easy to fit.

(3) The lower underarm and the upper underarm, and the wing back and the centre back are two positive pairs where either a good fit or a poor fit is achieved at the same time for both in the pair. There are four negative pairs where if one fits well, the fit of the other will be worse; these are centre front and wing back, centre underband and high point of

the bust, upper underarm and high point of the bust, upper underarm and centre neck edge.

(4) The greatest pressure and discomfort sensations occur in the underband and strap areas, and the least pressure and discomfort sensations occur in the cup areas. Women with a larger back size tend to feel weaker pressure sensations in the centre front area, whilst women who require larger cup sizes tend to feel stronger pressure sensations in the strap and back areas. The degrees of the sensations experienced in some areas have correlations with the extents of the misfittings in these areas. It was found that there is a strong positive correlation between the magnitudes of the same kind of sensations in different areas, e.g. a large pressure sensation in the cup area was accompanied by a large pressure sensation across the back area. There is also some degree of positive correlation between the magnitudes of the different kind of sensations in some of the areas, e.g. a large pressure sensation in the cup area was accompanied by a large discomfort sensation in the same area.

(5) By using K-means cluster analysis, it was shown that the wearers' sensations of pressure, discomfort and pain are quite different for different areas of the bra, and the sensations in some areas have correlations to other areas. The subjects can be grouped based on the amount of their sensations. They were divided into 5 groups by pressure sensation, into 5 groups by discomfort sensation and into 4 groups by pain sensation. Within each group, the subjects displayed similar characteristics in their assessment of the sensation.

(6) For almost all of the subjects, as the underbust girth decreases, the pressure, the pressure sensation, the discomfort sensation and the pain sensation increased; whilst, as the measured pressure increases, the pressure sensation, the discomfort sensation and the pain sensation also increases. For most subjects, the highest pressures were measured in the underband and underwire areas of the bra, and, in contrast, relatively weaker pressures were found in the upper part of the bra, the bra cup and the centre back. The strongest sensations of pressure were reported in the underband, underwire and back areas of the bra, and the weakest pressure sensations were reported in the high point of bust. The strongest sensations of discomfort were reported in the back areas of the bra,

and the weakest discomfort sensations were reported in the high point of bust. There were only a few reports of pain in the underband, underwire and the back areas of the bra, whilst no pain sensations were reported in other areas.

(7) The analysis of the pressure and sensations revealed that the underband and underwire areas are less sensitive to a feeling of pressure than other areas. The most sensitive area is the bra back for most subjects, although the pressure is not high in this area. It is found that there is a significant increase in the degree of the sensation as the underbust girth of the bra decreases.

(8) With regard to the straps, the analysis showed that pressure and the sensations of pressure, discomfort and pain are reduced with increasing the strap length. However, their sensations are increased with increasing the pressure at the strap.

(9) Analysis were carried out within the groups of subjects divided by the calculated bra sizes. The measured pressure values in different areas of the bra are similar for smaller sized subjects with similar calculated bra size. In contrast, the measured pressure values in different areas of the bra vary considerably for larger sized subjects with similar calculated bra size. It seems that for larger-sized women, the back area is more sensitive to pressure than other areas, in comparison with smaller sized women. Examining the data for the underbust girth of the bra, the correct underbust girth is similar for smaller sized subjects with similar breast measurement, but it varies considerably for the larger-sized subjects with similar calculated bra size.

(10) Comparing the data on sensations from the survey and from tests, revealed that for smaller sized subjects, these two groups of data are, to some extent, similar in amount and characteristics, but for larger sized women, there is much disparity within these two groups of data. From above, it may be concluded that a general correct pressure distribution in different areas of the bra can be established to achieve a good fit for smaller sized women with similar breast sizes, and a correct underbust girth can also be determined for similar sized women with similar breast size. However it is more difficult to achieve this for larger sized women, which is why larger sized women find it is difficult to obtain a perfectly fitting bra when shopping. Due to the diversity in body shape and fat distributions in the breast area and the upper body shape of larger sized

women, it is not easy for them to achieve a good fit for the bra using the same sizing system as that applicable to smaller sized women. An individual analysis of their shape and problems of fitting is more appropriate in these cases.

(11) A further comparison of subjects with exactly the same measured underbust and overbust girth showed that their pressure distributions in the bra are similar, but the reported sensations of pressure, discomfort and pain are not always the same. This means that different subjects have their own unique sensitivities to pressure, discomfort and pain. Similarly, the comparison of subjects with exactly the same measured underbust girth, but different overbust girth revealed that their pressure distributions in the bra are similar, but the reported sensations of pressure, discomfort and pain differ. There is some suggestion in the data that women who need larger cup sizes tend to tolerate more pressure and discomfort than those who take smaller cup.

7.2 Contributions

It is considered that the expectations as given in the initial aims have been achieved and that the findings from this study may make a contribution to the issues affecting the correct fitting of bras.

The methodology employed in this research, using a psychophysical method, the Borg CR10 Scale, has not been previously used for investigating bra fitting issues, and it has been proved that this method can be applied quickly and easily. This demonstrates its future applicability for further research in this area.

The basic results from the survey revealed information about bra wearers and their bra wearing characteristics, elucidates the differing demands on their bras from wearers with different characteristics. For bra fitting specialists and bra designers, present methods depend mainly on experience, this result, in comparison, can give some guidance based on scientific methodology. For bra fitting specialists, the results can be used to analyze the

preferences of the customers, can help wearer to select correct bras based on their body shape or bra wearing habits. For bra designers, the information of the fitting problems in different areas of the bra can be used to improve designs and decrease iterations of the trail and error.

The results of the survey of the sensations caused by wearing a bra provide a general picture of the pressure, the sensations of discomfort and pain in different areas of the bra. As previous research has seldom concentrated in such detail on the sensations experienced by the wearer when wearing a bra, it is considered that these results provide a new method for investigating the fit of bras. The classification of the respondents based on the sensations reported provides a descriptive framework, which can be used to provide guidance to bra designers and bra fitting specialists.

The results from pressure and sensations tests show more detailed characteristics about pressure and the wearers' sensations. Some useful findings may be used directly to obtain an improved fit of the bra for the wearer. The information of the characteristics of the pressures and the sensations of pressure, discomfort and pain in different areas of the bra can be used as guidance by bra designers and garment technologists during their design and fitting procedure to improve the fit and decrease the time of the product development.

7.3 Recommendations for future study

Although much survey and experimental work was undertaken in this research and though some useful findings were obtained from the large amount of data generated, it is still only a beginning in the use of psychophysical methods to analyse the bra fitting problems. This study is just a preliminary investigation into the measurement of pressure, and the sensations of pressure, discomfort and pain caused by wearing a bra. Further work is needed to investigate this subject in more depth. It is recommended that future investigation be carried out in the following areas:

(1) The survey should be expanded to include more women from different parts of the world, from different background and age groups and with other differentiating characteristics to obtain more broad data.

(2) The number of subjects for the bra pressure and sensation tests conducted in this research is not nearly enough to obtain more applicable data and findings. Therefore, more subjects, especially with similar breast sizes, should be enrolled in the any future work.

(3) This research used just one style of bra from one manufacturer, but it may be speculated that for different bra patterns and styles, the pressure and sensation distributions are probably different, so in the future work, bras of different styles should be investigated.

(4) It may be easily understood that, when the wearer's body is moving, the pressure and sensations will certainly change in different areas of the bra. It may be that a bra is comfortable when the body is at rest, but it may be quite different when the body is moving. Therefore it is important to investigate the pressure and sensations caused by wearing a bra when the body is moving. In this research, the investigations were only carried out when the body was in an, erect, standing posture, so that it would seen that on of the next stages of the investigation would be while the body is moving.

(5) This research employed some basic analytic methods to analyse the data, but it can be seen the data obtained from this project is massive and complicated. It is believed there may be more useful information within the data, but the analytic methods used were not sophisticated enough to disclose it. In future work, newly developed data analysis methods, such as data mining, could probably be used to extract more information from the research in this area.

References

ABC Science (2000) *Smart Bra to give support when it's needed.* [online]. ABC Science. Available from: http://www.abc.net.au/science/news/stories/s131388.htm [Accessed 3rd May 2006].

Amazon (2006) *Bra products catalogue.* [online]. Amazon. Available from: http://www.amazon.com [Accessed 20 Sep 2006].

Bare Necessities (2006) *The bra primer at bare necessities.* [online]. Bare Necessities. Available from: http://www.barenecessities.com/glossary_bra.asp [Accessed 20 Sep 2006].

Bellis. M. (2006) *The history of the brassiere.* [online]. About .com. Available from: http://inventors.about.com/library/weekly/aa042597.htm [Accessed 1st Many 2006].

Photo gallery: Bemis Sewfree Introduction. [CD-ROM]. (2006) Lincolnshire, Bemis Associates UK.

Bookrags (2006) *Bra.* [online]. Bookrags. Available from: http://www.bookrags.com/history/popculture/bra-bbbb-01/ [Accessed 20 Sep 2006].

Borg, G. (1998) *Borg's Perceived Exertion and Pain Scales.* Human Kinetics.

Bra size.org (2006) *Measuring for the proper bra size.* [online]. Bra size.org. Available from: http://www.brasize.org/ [Accessed 03 Oct 2006].

Chan, A.P. and Fan, J. (2002) Effect of clothing pressure on the tightness sensation of girdles. *International Journal of Clothing Science and Technology*, 14(2), 100-110.

Chen, D. and Zhao, Q. (2003) A study on clothing pressure for men's suit comfort evaluation. *International Journal of Clothing Science and Technology*, 15(5), 320-334.

Coren, S et al. (1993) *Sensation and perception.*, Harcourt Brace College Publishers.

Fan, J. and Chan, A.P. (2005) Prediction of girdle's pressure on human body from the pressure measurement on a dummy. *International Journal of Clothing Sciences and Technology*, 17(1), 6-12.

Figleaves (2006) *Bra glossary*. [online]. Figleaves. Available from: http://www.figleaves.com/uk/fitting_room.asp?cat=132&txt=2677 [Accessed 20 Sep 2006].

Figleaves (2006) *Bra products catalogue.* [online]. Figleaves. Available from: http://www.figleaves.com [Accessed 20 Sep 2006].

Fowler, F.J. (2002) *Survey research methods.* Sage Publications.

Goonetilleke, R.S. (1998) Designing to minimize discomfort. *Ergonomics in Design*, 6(3), 12-19.

Greenbaum, A.R., Heslop, T., Morris, J. and Dunn, K.W. (2003) An investigation of the suitability of bra fit in women referred for reduction mammaplasty. *British Journal of Plastic Surgery*, 56, 230-236.

Hawthorne, R. (1992) *Bras, a private view.* Souvenir Press.

Herroom (2006) *Bra fitting*. [online]. Herroom. Available from: http://www.herroom.com/all-about-bra-fitting,201,30.html [Accessed 3rd Oct 2006].

Hertzberg, H.T.E. (1972) The human buttock in sitting: Pressures, patterns, and Palliatives. *American Automobile Transactions*, 72, 39-47.

Hsieh, C.C. and Trichopoulos, D. (1991) Breast size, handedness and breast cancer risk. *Eur J Cancer*, 27(2), 131-5.

Imaginis (2006) *Breast pain*. [online]. Imaginis. Available from: http://www.imaginis.com/index.html [Accessed 15 May 2006].

Komotv (2006) *Breast Cancer: Definition, Description and Causes*. [online]. Komotv. Available from: http://ww3.komotv.com/Global/story.asp?S=3601313 [Accessed 15 May 2006].

Krenzer, G., Starr, C. and Branson, D. (2005) Excellence in design - Development of a sports bra prototype. *Clothing and Textiles Research Journal*, 23(2), 131-134.

Lane Bryant (2006) *Bra glossary*. [online]. Lanebryantcatalog. Available from: http://www.lanebryantcatalog.com/Department.aspx?DeptId=11412 [Accessed 20 Sep 2006].

Li, Y., Zhang, X and Yeung, K.W. (2003) A 3D biomechanical model for numerical simulation of dynamic mechanical interactions of bra and breast during wear. *Sen'i-Gakkaishi*, 59(1), 12-21.

Litwin, M.S. (2002) *How to assess and interpret survey psychometrics*. Sage Publications.

Makabe, H., Momota, H., Mistsuno, T. and Ueda, K. (1991a) A study of clothing pressure developed by the brassiere. *Journal of the Japan Research Association for Textile end-Uses*, 32(9), 416-423.

Makabe, H., Momota, H., Mistsuno, T. and Ueda, K. (1991b) A study of clothing pressure developed by the girdle. *Journal of the Japan Research Association for Textile end-Uses*, 32(9), 424-438.

Makabe, H., Momota, H., Mitsuno, T. and Ueda, K. (1993) Effect of covered area at the waist on clothing pressure. *Sen-i-Gakkaishi*, 49(10), 513-521.

Mayo Clinic (2005) *Benign breast disease an important breast cancer risk factor*. [online]. Rochester, Mayo Clinic. Available from: http://www.mayoclinic.org/news2005-rst/2965.html [Accessed 5th May 2006].

Mintel (2003) *Bras and Pants - UK - September 2003*. [online]. Mintel. Available from: http://reports.mintel.com [Accessed 5th May 2006].

Mintel (2005a) *Bras and Pants - UK - September 2005*. [online]. Mintel. Available from: http://reports.mintel.com [Accessed 5th May 2006].

Mintel (2005b) *Underwear Retailing - UK - April 2005*. [online]. Mintel. Available from: http://reports.mintel.com [Accessed 5th May 2006].

Mintel (2006) *Underwear Retailing - UK - April 2006*. [online]. Mintel. Available from: http://reports.mintel.com [Accessed 5th May 2006].

Morris, D. (2004a) *Bra sizing: Handout of Bra Design Short Courses*. De Montfort University.

Morris, D. (2004b) *The breast and bra fitting issues(1): Handout of Bra Design Short Courses*. De Montfort University.

Morris D. (2004c) *The breast and bra fitting issues(2): Handout of Bra Design Short Courses*. De Montfort University.

Morris D. (2004d) *The breast and bra fitting issues(3): Handout of Bra Design Short Courses*. De Montfort University.

Morris D. (2004e) *The breast and bra fitting issues(4): Handout of Bra Design Short Courses*. De Montfort University.

M&S (2006) *Bra sensor.* [online]. Marks and Spencer. Available from: http://www2.marksandspencer.com/storesplus/features/innovations/bra_sensor/bra_sensor.shtml [Accessed 08th Sep 2006].

Nakahashi, M., Morooka, H., Morooka, H., Hirage, S. and Deguchi, J. (1999) Effect of clothing pressure on front and back of lower leg on compressive feeling. *Journal of the Japan Research Association for Textile end-Uses*, 40(10), 49-56.

Nakahashi, M., Morooka, M. and Morooka, H. (2000) An estimation of the comfortable and critical clothing pressure values on legs, and an analysis of factors affecting those values. *Journal of the Japan Research Association for Textile end-Uses*, 41(9), 756-762.

Neumann, E.S. (2001a) Measurement of socket discomfort-part I: Pressure sensation. *Journal of Prosthetics and Orthotics*, 13(4), 99-110.

Neumann, E.S. (2001b) Measurement of socket discomfort- Part II: Signal detection. *Journal of Prosthetics and Orthotics*, 13(4), 111-122.

Okabe, K. and Kurokawa, T. (2003) Vibration characteristics of breasts during exercise with and without a brassiere. *Jouranl of Home Economics of Japan*, 54(9), 731-738.

Onehanesplace (2006) *Bra glossary*. [online]. Onehanesplace. Available from: http://www.onehanesplace.com/webapp/commerce/command/ExecMacro/info.d2w/report?info=braglossary [Accessed 21st Set 2006].

Open Ergonomics. (2001) *Bra sensor care and maintenance instructions*. Open Ergonomics.

Pechter, E.A. (1998) A new method for determining bra size and predicting postaugmentation breast size. *Plastic and Reconstructive Surgery*, 102(4), 1259-65.

Pedersen, S. (2004) *Bra, a thousand years of style, support and seduction*. David & Charles.

Probe, A. (2005) Are European sizes mad?. *TextiWirtschaft*, 16, 46-47.

Salt, H.L. (2003) *Capturing female breast shape through modeling: A new method of obtaining 3D breast data for bra design*. Unpubloished MSc Dissertation, De Montfort University.

Salzmann. *Salzmann MEDICO MST MK III operating manual*. Salzmann Ltd.

Sasaki, K., Miyashita, K., Edamura, M., Furukawa, T., Shimizu, Y and Shimizu, H. (1997) Evaluation of foundation comfort based on the sensory evaluation and dynamic clothing pressure measurement. *Journal of the Japan Research Association for Textile end-Uses*, 38(2), 53-59.

Schlomski, I. (2001) Half of all women are wearing the wrong size of bra-it's no wonder, *Maschen Industrie*, 7, 38-40.

Seer's (2006) *Breast anatomy*. [online]. Seer's training web site. Available from: http://training.seer.cancer.gov/ss_module01_breast/unit02_sec01_anatomy.html [Accessed 15th May 2006].

Shimizu, Y., Tozuka, U., Otsuka, I. and Matsushima, T. (1987) Survey on the wearing conditions of underwear. *Journal of the Japan Research Association for Textile end-Uses*, 28(1), 23-30.

Shimizu, Y., Sasaki, K., Watanabe, K., Konda, A., Kato, Y. and Shimizu, H. (1993) Dynamic measurement of clothing pressure on the body in a brassiere. *Sen-i-Gakkaishi*, 49(1), 57-62.

Singer, S.R. and Grismaijer, S. (2005) *Dressed to kill: The link between breast cancer and bras*. ISCD Press.

Smh.com.au (2002) *Looking for the perfect fit*. [online]. Smh.com.au. Available from: http://www.smh.com.au/articles/2002/06/11/1022982846387.html [Accessed 11th June 2006].

Sporteze (2006) *Post mastectomy sport bras*. [online]. Sporteze. Available from: http://sporteze.com/products/special.html [Accessed 20 Sep 2006].

SPSS. (2002) *Tutorial and case study of SPSS 11.5 for windows*. SPSS.

Talley (2006) *Talley SD.500 skin pressure evaluator*. [online]. Talley Group. Available from: http://www.talleygroup.com/sd500-usa.htm [Accessed 08th Sep 2006].

The Breast Site (2006) *Bras*. [online]. The Breast Site. Available from: http://www.thebreastsite.com/bras/ [Accessed 20 Sep 2006].

The Breast Site (2006) *Bra styles*. [online]. The Breast Site. Available from: http://www.thebreastsite.com/bras/bra-styles.aspx [Accessed 20 Sep 2006].

Trochim, W.M (2006) *Scaling*. [online]. Social Research Methods. Available from: http://www.socialresearchmethods.net/kb/scaling.htm [Accessed 20th Feb 2006].

Tsuchida, K. and Harada, T. (1988) The relation between the tensile properties of clothing materials and the clothing pressure. *Journal of the Textile Machinery Society of Japan*, 41(7), 375-384.

University of Wollongong (2005) *New consumer study reveals women's bras don't measure up*. [online]. University of Wollongong. Available from: http://media.uow.edu.au/news/2005/0722a/index.html [Accessed 22nd July 2005].

University of Wollongong (2000) *Smart bra heralds new age of intelligent fabrics*. [online]. University of Wollongong. Available from: http://media.uow.edu.au/archive/oldbytes12/cnews/page4.html [Accessed 16th Apr 2003].

Utexas (2006) *Scheme of Breast Anatomy*. [online]. Utexas. Available from: http://www.me.utexas.edu/REALSurvivors/images/breast_anatomy.jpg [Accessed 20th Sep 2006].

Wright, M.C.M. (2002) Graphical analysis of bra size calculation procedures. *International Journal of Clothing Science and Technology*, 14(1), 41-45.

Wikipedia (2006) *Brassiere*. [online]. Wikipedia. Available From: http://en.wikipedia.org/wiki/Brassiere [Accessed 15th May 2006].

Zhang, L. Helander, M.G. and Drury, C.G. (1996) Identifying factors of comfort and discomfort in sitting. *Human Factors*, 38(3), 377-389.

Appendix A: Questionnaire used in the pilot survey

No.: _____ Date: _____

Time: _____

Woman's Bra Pressure and Comfort Survey

This is a questionnaire that deals with woman's bra, which is a part of PhD research. Please take a few minutes to express your wearing habits, opinions and feelings about woman's bra. Your answers are important to the success of this study.
Thank you for your assistance.

Part 1: The questions listed below are about your demographic characteristics. I am asking these questions in order to determine if various groups have different attitude towards bra. All information will be treated as confidential.

Q.1. What is your AGE?

- ☐ Below 16 (End of the Survey)
- ☐ 16-19
- ☐ 20-24
- ☐ 25-39
- ☐ 40-44
- ☐ 45-49
- ☐ 50-54
- ☐ 55-59
- ☐ 60 and over

Q.2. What is your HEIGHT? _____ feet _____ inches or _____ centimetres

Q.3. What is your WEIGHT? _____ pounds or _____ kilograms

Q.4. What is your ETHNIC ORIGIN?

- ☐ White - British
- ☐ White - Irish
- ☐ Other White background, please specify _____
- ☐ Black or Black British - Caribbean
- ☐ Black or Black British - African
- ☐ Other Black background, please specify _____
- ☐ Asian or Asian British - Indian
- ☐ Asian or Asian British - Pakistani
- ☐ Asian or Asian British - Bangladeshi
- ☐ Chinese
- ☐ Other Asian background, please specify _____
- ☐ Mixed - White and Black Caribbean
- ☐ Mixed - White and Black African
- ☐ Mixed - White and Asian
- ☐ Other Mixed background, please specify _____
- ☐ Other Ethnic background, please specify _____

Part 2: Questions about women's bra wearing habit

Q.5. Do you wear a bra during your daily life, please select an option that best describes your WEARING HABIT about bras.

- ☐ Wearing a bra at all times including sleeping hours
- ☐ Wearing a bra during waking hours
- ☐ Only wearing a bra outside the home
- ☐ Only wearing a bra in some special occasions
- ☐ Only wearing bra occasionally
- ☐ Never wearing a bra (End of the survey)
- ☐ Others, please specify _____

Q.6. HOW LONG do you wear a bra during a day?

Approximately _____ Hours

Q.7. When you BEGAN to wear bra?

Approximately at the age of _____

Q.8. What is your BRA SIZE?

Back size:

- ☐ 30
- ☐ 32
- ☐ 34

Cup size:

- ☐ AA
- ☐ A
- ☐ B

☐ 36
☐ 38
☐ 40
☐ 42
☐ 44
☐ 46
☐ Over 46, please specify _____

☐ C
☐ D
☐ DD
☐ E
☐ F
☐ G
☐ Over G, please specify _____

Q.9. How many bras do you own?

☐ 0-5
☐ 6-10
☐ 11-15
☐ 16-20
☐ 21-25
☐ 25 and over

Q.10. Approximately how many new bras have you gained (including purchase and gift) in the last year?

☐ 0
☐ 1-2
☐ 3-5
☐ 6-8
☐ 9-12
☐ 13-15
☐ 16 and over

Q.11. On average, how soon will you discard a bra after your first wearing?

☐ Within 1 month
☐ 2-3 months
☐ 4-6 months
☐ 7-9 months
☐ 9-12 months
☐ 1-1.5 years
☐ 1.5-2 years
☐ 2 years and over

Q.12. Do you wear a bra when you are doing exercise?

☐ Yes

Which kind of bra do you wear when doing exercise?

☐ The same bra as I wear for normal life
☐ Sports bra
☐ Only a sports bra during extreme exercise

☐ No

Can you specify the reasons?

☐ I like to wear a tight vest during exercise.
☐ The bra makes me feel uncomfortable during exercise.
☐ Others, please specify_____

Q.13. Have you had any medical problems with your breasts?

☐ No
☐ Yes.

Does it influence your bra selection, wearing habits of bra or other things connected with bras?

☐ No
☐ Yes, can you specify how? _____

Q.14. Have you experienced wearing different sized bra?

☐ No, I just wear the same sized bra.
☐ Yes.

Why you wear different sized bra?

☐ Due to the small discrimination among different styles, brands and so on
☐ Due to the change of body shape and weight
☐ Due to pregnancy
☐ Due to breast surgery
☐ Others, please specify _____

Part 3: Questions about women's attitudes about bras

Q.15. Listed below are some statements about bra, please specify how strongly you agree or disagree with the following statements.

	Strongly agree	Agree	neutral	Disagree	Strongly disagree	Not sure
Bra is an IMPORTANT garment for women.	☐	☐	☐	☐	☐	☐
Bra is an ESSENTIAL garment for women.	☐	☐	☐	☐	☐	☐
Bra is a GOOD garment for women.	☐	☐	☐	☐	☐	☐
Bra can provide a fashionable shape to the breasts.	☐	☐	☐	☐	☐	☐
Some kinds of bra can distort the shape of breasts.	☐	☐	☐	☐	☐	☐
Tighter bra can provide better breast shape.	☐	☐	☐	☐	☐	☐
I think that not wearing a bra is more natural.	☐	☐	☐	☐	☐	☐
I prefer not to wear a bra.	☐	☐	☐	☐	☐	☐
I think it is socially correct to wear a bra.	☐	☐	☐	☐	☐	☐

Bra can provide support to the breast.	☐	☐	☐	☐	☐	☐
Wearing a bra is more comfortable.	☐	☐	☐	☐	☐	☐
I'd like to sacrifice comfort for an improvement in breast shape and support	☐	☐	☐	☐	☐	☐
I am happy to improve my breast shape and support by wearing a bra using harmless NON-FABRIC materials, such as polymer, rubber.	☐	☐	☐	☐	☐	☐

Q.16. Do you think wearing a bra can increase or reduce the chance of having breast health problems?

☐ I think wearing a bra can increase the chance of having breast health problems.
☐ I think wearing a bra can reduce the chance of having breast health problems.
☐ I don't care if wearing a bra can increase or reduce the chance of having breast health problems.
☐ Not sure.

Q.17. What STYLE of bra do you prefer? (Multi-selection)

- ☐ Non-padded underwired bra
- ☐ Padded underwired bra
- ☐ Soft non-padded bra
- ☐ Soft padded bra
- ☐ Balcony bra
- ☐ Push up bra
- ☐ Strapless bra
- ☐ Soft fabric moulded bra
- ☐ T-shirt bra
- ☐ Other, please specify _____

Q.18. What kind of support of bra do you prefer?

- ☐ Full support
- ☐ Medium support
- ☐ Light support

Q.19. Listed below are some PROPERTIES of bra, Do you think which one is MOST important, and which one is LEAST important? Please put these properties into NUMBER ORDER from most important to least important.

1. Fit
2. Comfort
3. Quality
4. Material
5. Breast support
6. Price
7. Brand
8. Style
9. Color

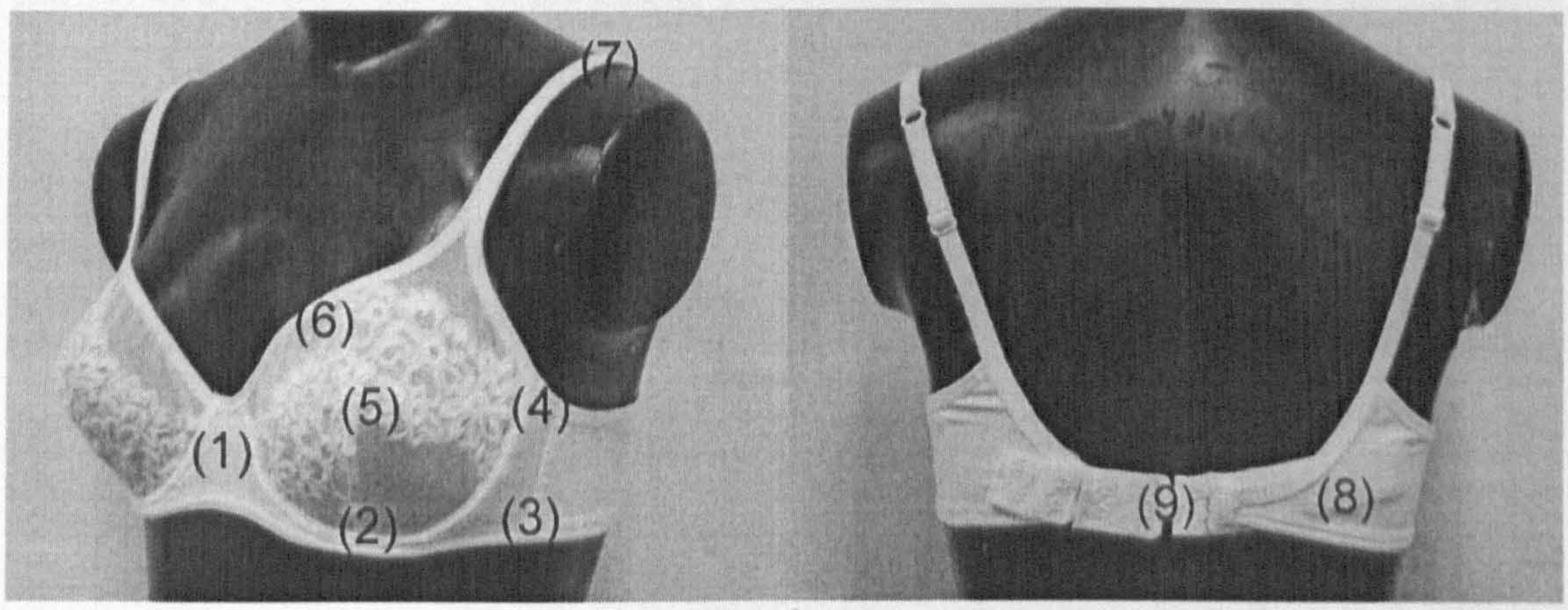
Q.20. Do you satisfied with the existing bra products in both retail and mail order?

- ☐ Yes
- ☐ No, please specify the reasons (Multi-selection)
  - ☐ I can not find my SIZE.
  - ☐ I am not satisfied with the COMFORT property of the bra.
  - ☐ I am not satisfied with the QUALITY of the bra.
  - ☐ The existing bra can not offer enough SUPPORT to my size.
  - ☐ I am not satisfied with the MATERIAL used.
  - ☐ I am not satisfied with the STYLE.
  - ☐ I am not satisfied with the COLOR.
  - ☐ Others, please specify _____

Q.21. Can you always find a PERFECT FIT bra?

☐ Yes

☐ No, according to Figure, please specify which parts of the bra are mostly difficult to fit your breasts (multi-selection)

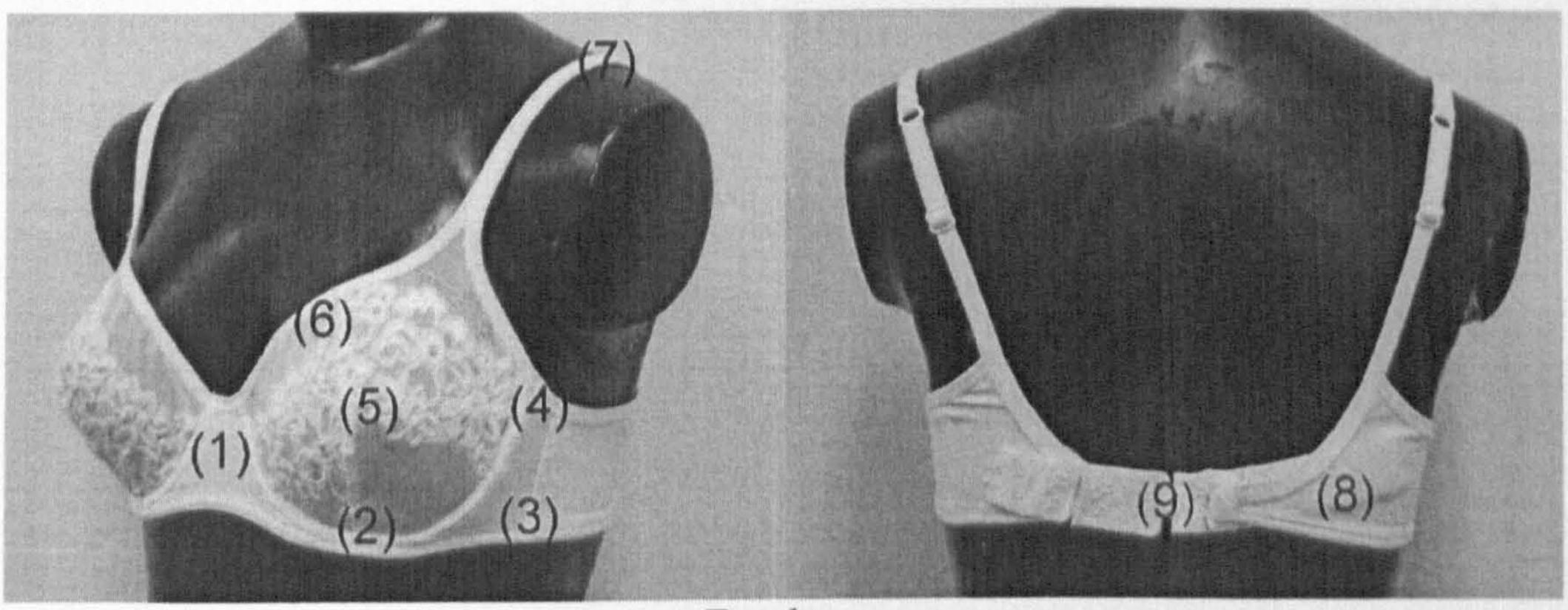


Focal areas

☐ The area 1
☐ The area 2
☐ The area 3
☐ The area 4
☐ The area 5
☐ The area 6
☐ The area 7
☐ The area 8
☐ The area 9

Part 4: Questions about women's pressure and discomfort sensation to wearing bras

Q.22. During your daily life, when you are wearing a bra, can you select an option that best describes the amount of PRESSURE or TIGHTNESS you feel in different areas of the bra (The areas showed in Figure)?



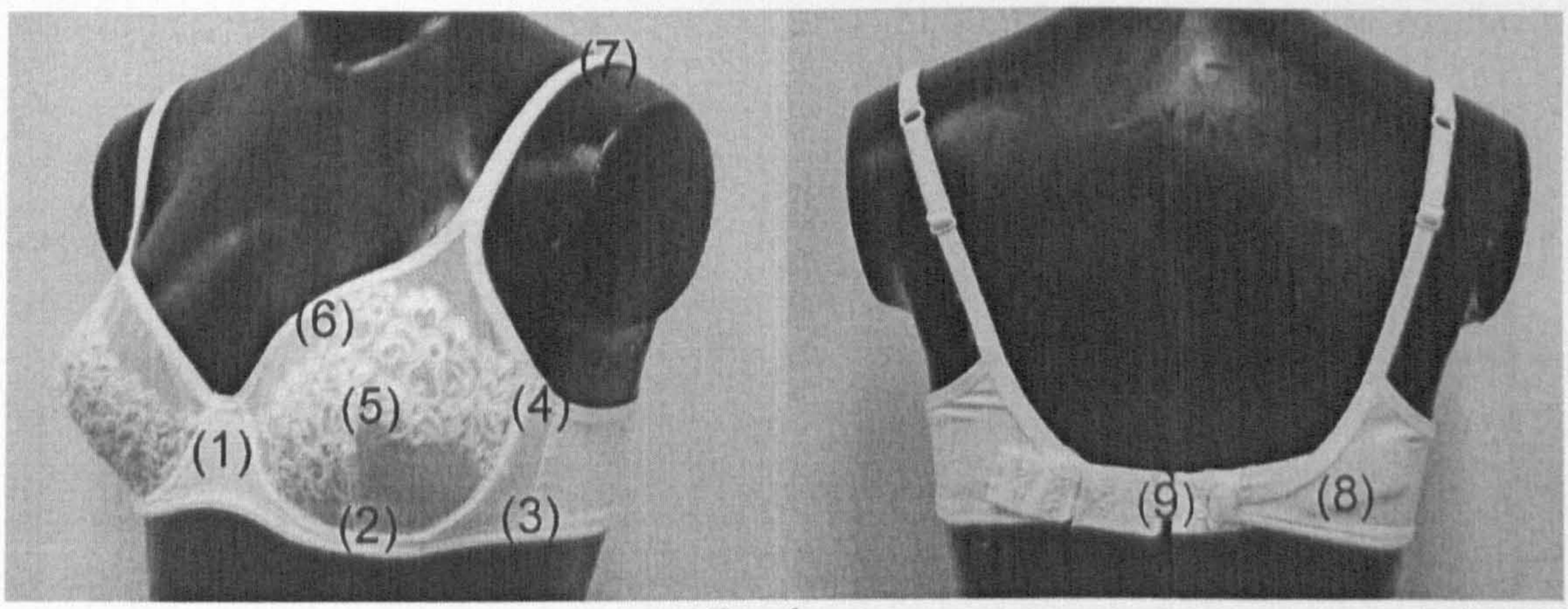
Focal areas

	Very strong	Strong	average	light	Very light	none
The PRESSURE in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

Q.23. Some women experience discomfort when wearing bra. Do you think the discomfort of bra is totally caused by pressure? That means do you think the pressure sensation and the discomfort sensation caused by bra are the same?

☐ Yes

☐ No, can you select an option that best describes the amount of DISCOMFORT you feel in different areas of the bra (The areas showed in Figure).



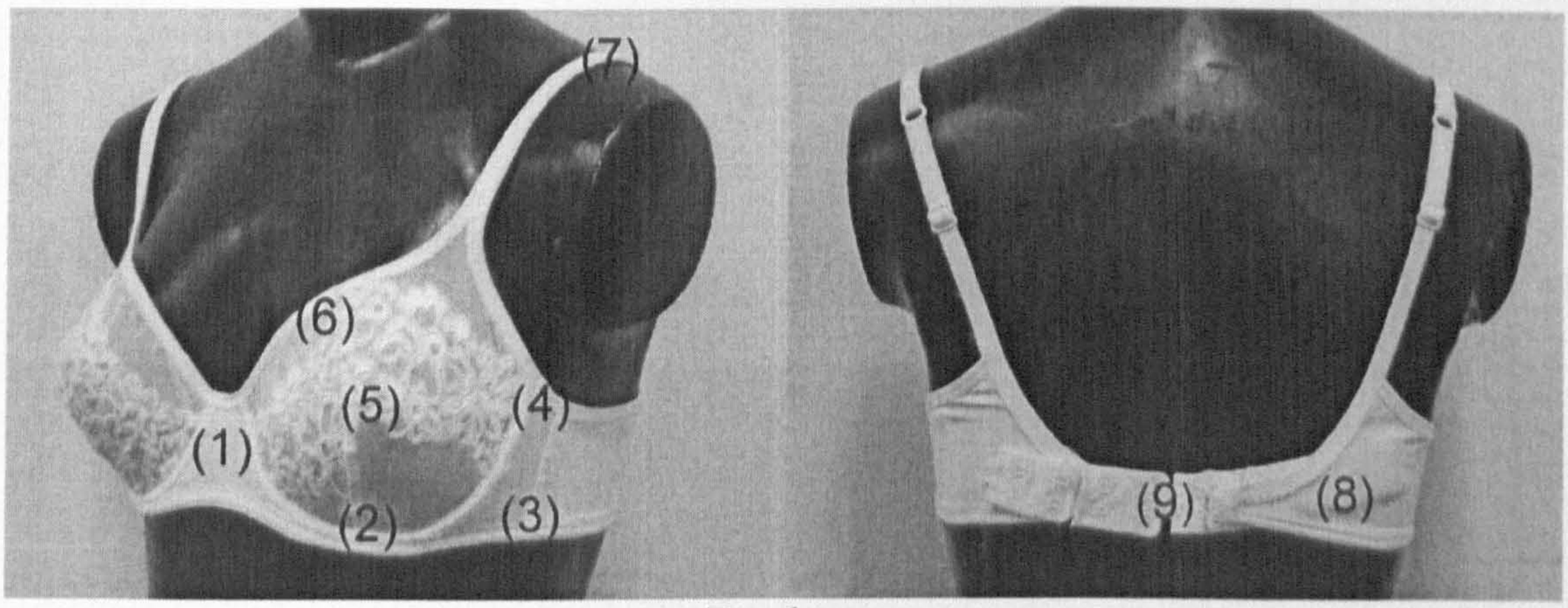
Focal areas

	Very strong	Strong	average	light	Very light	none
The DISCOMFORT in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

Q.24. Do you experience any PAIN when you wearing a bra during your daily life?

☐ No

☐ Yes, can you select the level of pain in the following areas of the bra (The areas showed in Figure)?



Focal areas

	Very severe	Severe	Average	Light	Very light	None
The PAIN occurs in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

(The End)

Thanks a lot for your assistance.

Appendix B: Questionnaire used in the survey (English version)

No.: _____ Date: _____

Woman's Bra Pressure and Comfort Survey

This is a questionnaire that deals with woman's bra, which is a part of PhD research. Please take a few minutes to express your wearing habits, opinions and feelings about woman's bra. Your answers are important to the success of this study.
Thank you for your assistance.

Part 1: The questions listed below are about your DEMOGRAPHIC characteristics. I am asking these questions in order to determine if various groups have different attitude towards bra. All information will be treated as confidential.

Q.1. What is your AGE?

- ☐ Below 16 (End of the Survey)
- ☐ 16-20
- ☐ 21-25
- ☐ 26-30
- ☐ 31-35
- ☐ 36-40
- ☐ 40-45
- ☐ 46-50
- ☐ 51-55
- ☐ 56-60
- ☐ 61 and over

Q.2. What is your HEIGHT? _____ feet _____ inches or _____ centimetres

Q.3. What is your WEIGHT? _____ pounds or _____ kilograms

Q.4. What is your ETHNIC ORIGIN?

- ☐ White - British
- ☐ White - Irish
- ☐ Other White background, please specify _____
- ☐ Black or Black British - Caribbean
- ☐ Black or Black British - African
- ☐ Other Black background, please specify _____
- ☐ Asian or Asian British - Indian
- ☐ Asian or Asian British - Pakistani
- ☐ Asian or Asian British - Bangladeshi
- ☐ Chinese
- ☐ Other Asian background, please specify _____
- ☐ Mixed - White and Black Caribbean
- ☐ Mixed - White and Black African
- ☐ Mixed - White and Asian
- ☐ Other Mixed background, please specify _____
- ☐ Other Ethnic background, please specify _____

Part 2: Questions about women's bra WEARING HABITS

Q.5. Do you wear a bra during your daily life, please select an option that best describes your WEARING HABIT about bras.

- ☐ Wearing a bra at all times including sleeping hours
- ☐ Wearing a bra during waking hours
- ☐ Only wearing a bra outside the home
- ☐ Only wearing a bra in some special occasions
- ☐ Only wearing bra occasionally
- ☐ Never wearing bra (End of the survey)
- ☐ Others, please specify _____

Q.6. HOW LONG do you wear a bra during a day?

Approximately _____ Hours

Q.7. When you BEGAN to wear a bra?

Approximately at the age of _____

Q.8. What is your BRA SIZE?

Back size:

- ☐ 30
- ☐ 32
- ☐ 34
- ☐ 36
- ☐ 38
- ☐ 40
- ☐ 42
- ☐ 44
- ☐ 46
- ☐ Over 46, please specify _____

Cup size:

- ☐ AA
- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ DD
- ☐ E
- ☐ F
- ☐ G
- ☐ Over G, please specify _____

Q.9. Approximately HOW MANY bras do you own?

- ☐ 0-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 and over, please specify _____

Q.10. Approximately HOW MANY new bras have you gained (including purchase and gift) in the last year?

- ☐ 0
- ☐ 1-2
- ☐ 3-5
- ☐ 6-8
- ☐ 9-12
- ☐ 13-15
- ☐ 16 and over, please specify _____

Q.11. On average, HOW SOON will you discard a bra after your first wearing?

- ☐ Within 1 month
- ☐ 2-3 months
- ☐ 4-6 months
- ☐ 7-9 months
- ☐ 9-12 months
- ☐ 1-1.5 years
- ☐ 1.5-2 years
- ☐ 2 years and over

Q.12. Do you wear a bra when you are DOING EXERCISE?

- ☐ Yes

  Which kind of bra do you wear when doing exercise?

  - ☐ The same bra as I wear for normal life
  - ☐ Sports bra

☐ Only a sports bra during extreme exercise

☐ Others, please specify_____

☐ No

Can you specify the reasons?

☐ I like to wear a tight vest during exercise.

☐ The bra makes me feel uncomfortable during exercise.

☐ Others, please specify_____

Q.13. Have you had any MEDICAL PROBLEMS with your breasts?

☐ No

☐ Yes.

Does it influence your bra selection, wearing habits of bra or other things connected with bras?

☐ No

☐ Yes, can you specify how? _____

Q.14. Have you experienced wearing DIFFERENT SIZED bra?

☐ No, I just wear the same sized bra.

☐ Yes.

Why you wear different sized bra? (Multi-selection)

☐ Due to the small discrimination among different styles, brands and so on

☐ Due to the change of body shape and weight

☐ Due to pregnancy

☐ Due to breast surgery

☐ Others, please specify _____

Part 3: Questions about women's ATTITUDES about bras

Q.15. Listed below are some STATEMENTS about bra, please specify HOW STRONGLY you agree or disagree with the following statements.

	Strongly agree	Agree	neutral	Disagree	Strongly disagree	Not sure
Bra is an IMPORTANT garment for women.	☐	☐	☐	☐	☐	☐
Bra is an ESSENTIAL garment for women.	☐	☐	☐	☐	☐	☐
Bra is a GOOD garment for women.	☐	☐	☐	☐	☐	☐
Bra can provide a fashionable shape to the breasts.	☐	☐	☐	☐	☐	☐
Some kinds of bra can distort the shape of breasts.	☐	☐	☐	☐	☐	☐
Tighter bra can provide better breast shape.	☐	☐	☐	☐	☐	☐
I think that not wearing a bra is more natural and more	☐	☐	☐	☐	☐	☐

comfortable.						
I prefer not to wear a bra.	☐	☐	☐	☐	☐	☐
I am wearing a bra just because it is socially correct, otherwise, I'd rather not wearing a bra.	☐	☐	☐	☐	☐	☐
Bra can provide support to the breast.	☐	☐	☐	☐	☐	☐
Wearing a bra is more comfortable.	☐	☐	☐	☐	☐	☐
I'd like to sacrifice comfort for an improvement in breast shape and support	☐	☐	☐	☐	☐	☐
I am happy to improve my breast shape and support by wearing a bra using harmless NON-FABRIC materials, such as polymer, rubber.	☐	☐	☐	☐	☐	☐

Q.16. Do you think wearing a bra can increase or reduce the chance of having breast HEALTH PROBLEMS?

☐ I think wearing a bra can increase the chance of having breast health problems.
☐ I think wearing a bra can reduce the chance of having breast health problems.
☐ I don't care if wearing a bra can increase or reduce the chance of having breast health problems.
☐ Not sure.

Q.17. What STYLE of bra do you prefer? (Multi-selection)

☐ Non-padded underwired bra
☐ Padded underwired bra
☐ Soft non-padded bra
☐ Soft padded bra
☐ Balcony bra
☐ Push up bra
☐ Strapless bra
☐ Soft fabric moulded bra
☐ T-shirt bra
☐ Other, please specify _____

Q.18. What kind of SUPPORT of bra do you prefer?

☐ Full support
☐ Medium support
☐ Light support

Q.19. Listed below are some PROPERTIES of bra, do you think which one is most important, and which one is least important? Please put these properties into NUMBER ORDER from MOST important to LEAST important.

1. Fit
2. Comfort
3. Quality
4. Material
5. Breast support
6. Price

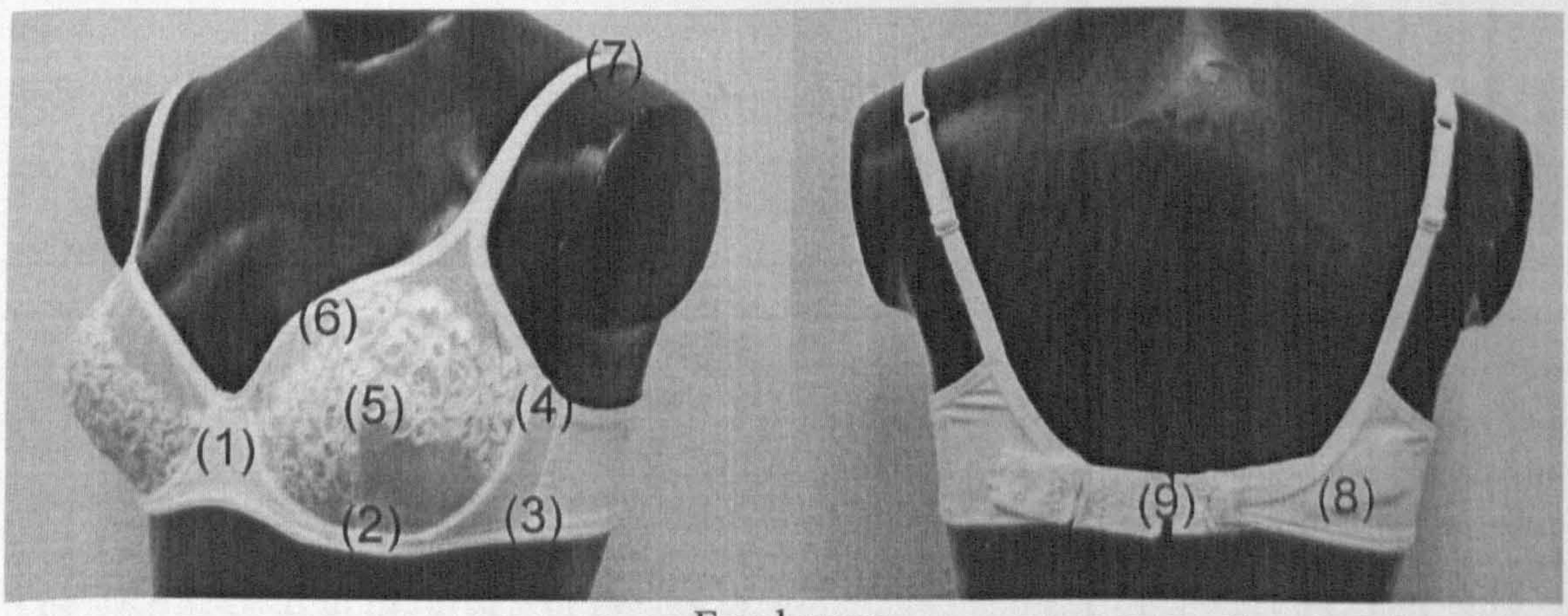
7. Brand
8. Style
9. Color

Q.20. Do you SATISFIED with the existing bra products in both retail and mail order?

☐ Yes
☐ No, please specify the reasons (Multi-selection)
- ☐ I can not find my SIZE.
- ☐ I am not satisfied with the COMFORT property of the bra.
- ☐ I am not satisfied with the QUALITY of the bra.
- ☐ The existing bra can not offer enough SUPPORT to my size.
- ☐ I am not satisfied with the MATERIAL used.
- ☐ I am not satisfied with the STYLE.
- ☐ I am not satisfied with the COLOR.
- ☐ Others, please specify _____

Q.21. Can you always find a PERFECT FIT bra?

☐ Yes
☐ No, according to Figure, please specify which parts of the bra are mostly difficult to fit your breasts (multi-selection)

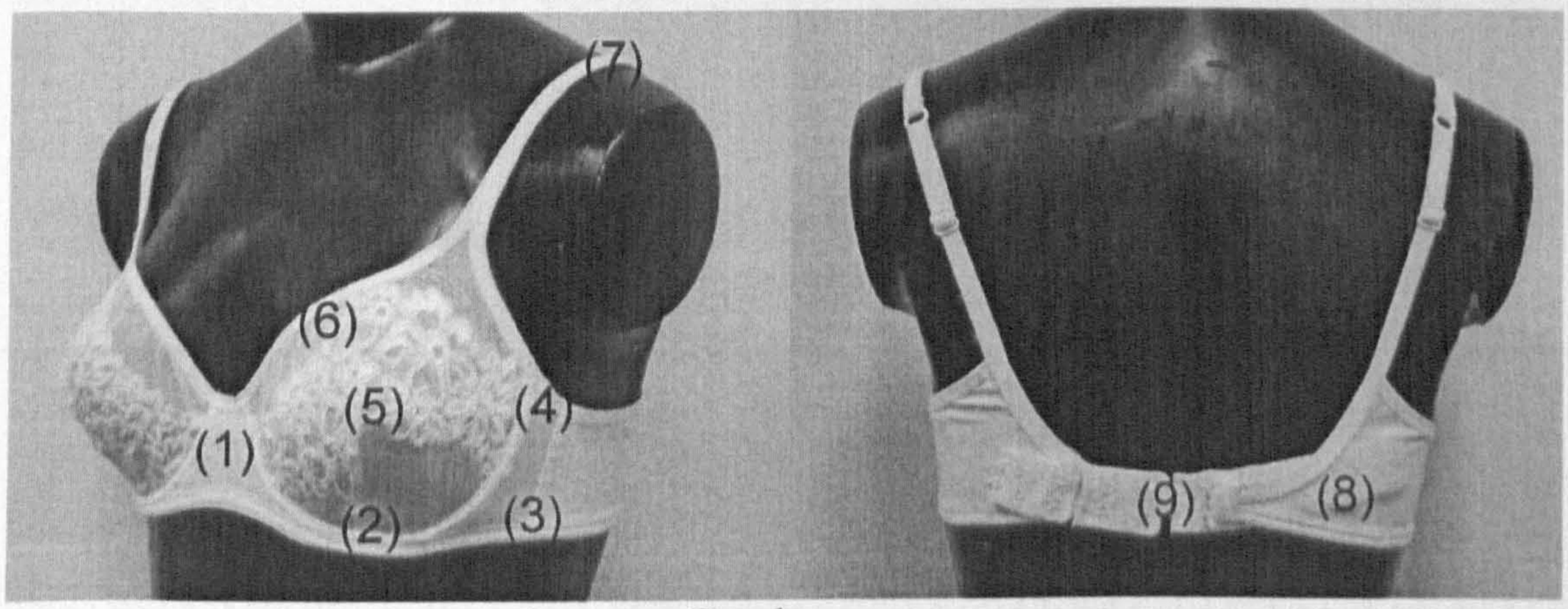


Focal areas

☐ The area 1
☐ The area 2
☐ The area 3
☐ The area 4
☐ The area 5
☐ The area 6
☐ The area 7
☐ The area 8
☐ The area 9

Part 4: Questions about women's PRESSURE and DISCOMFORT sensation to wearing bras

Q.22. When you are wearing a bra, reference to daily wear bras, can you select an option that best describes the amount of PRESSURE or TIGHTNESS you feel in different areas of the bra (The areas showed in Figure)?



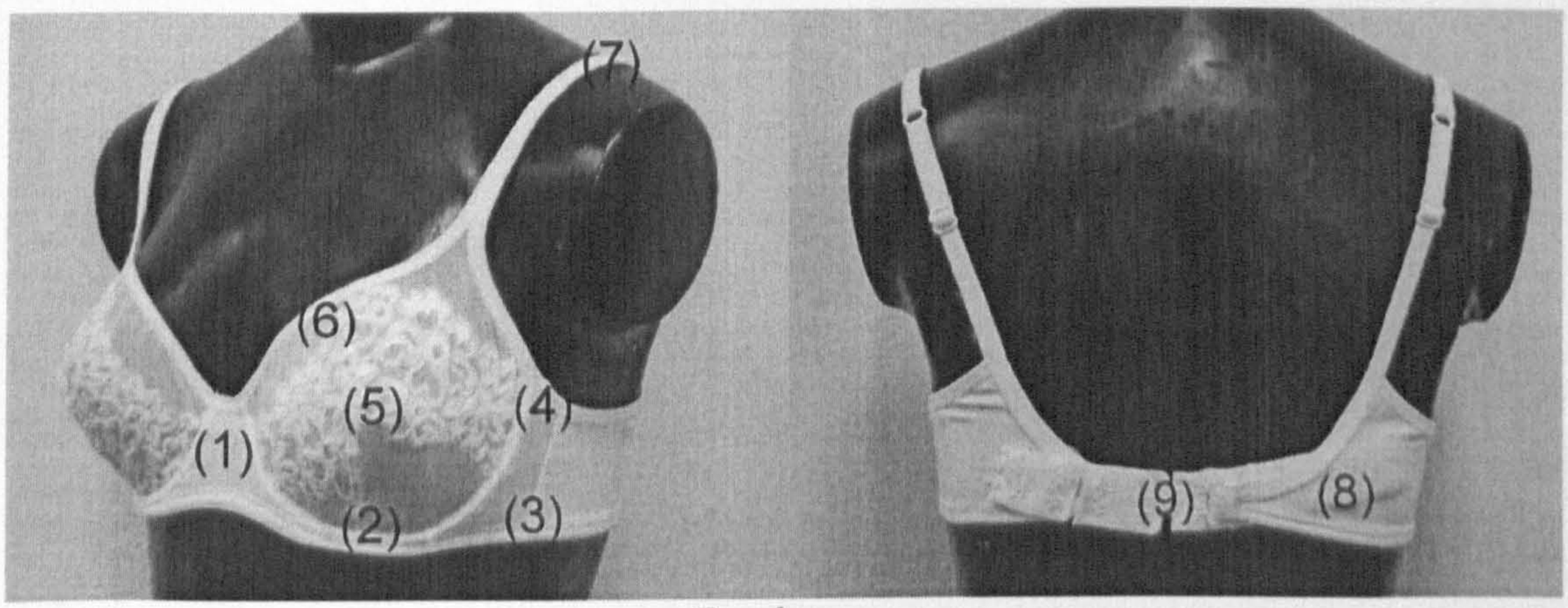
Focal areas

	Very strong	Strong	Average	Light	Very light	none
The PRESSURE in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The PRESSURE in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

Q.23. Some women experience discomfort when wearing bra. Do you think the discomfort of bra is totally caused by pressure? That means do you think the PRESSURE sensation and the DISCOMFORT sensation caused by bra are the same?

☐ Yes (Skip to Q.25)
☐ No (Go to Q.24)

Q.24. Can you select an option that best describes the amount of DISCOMFORT you feel in different areas of the bra (The areas showed in Figure).



Focal areas

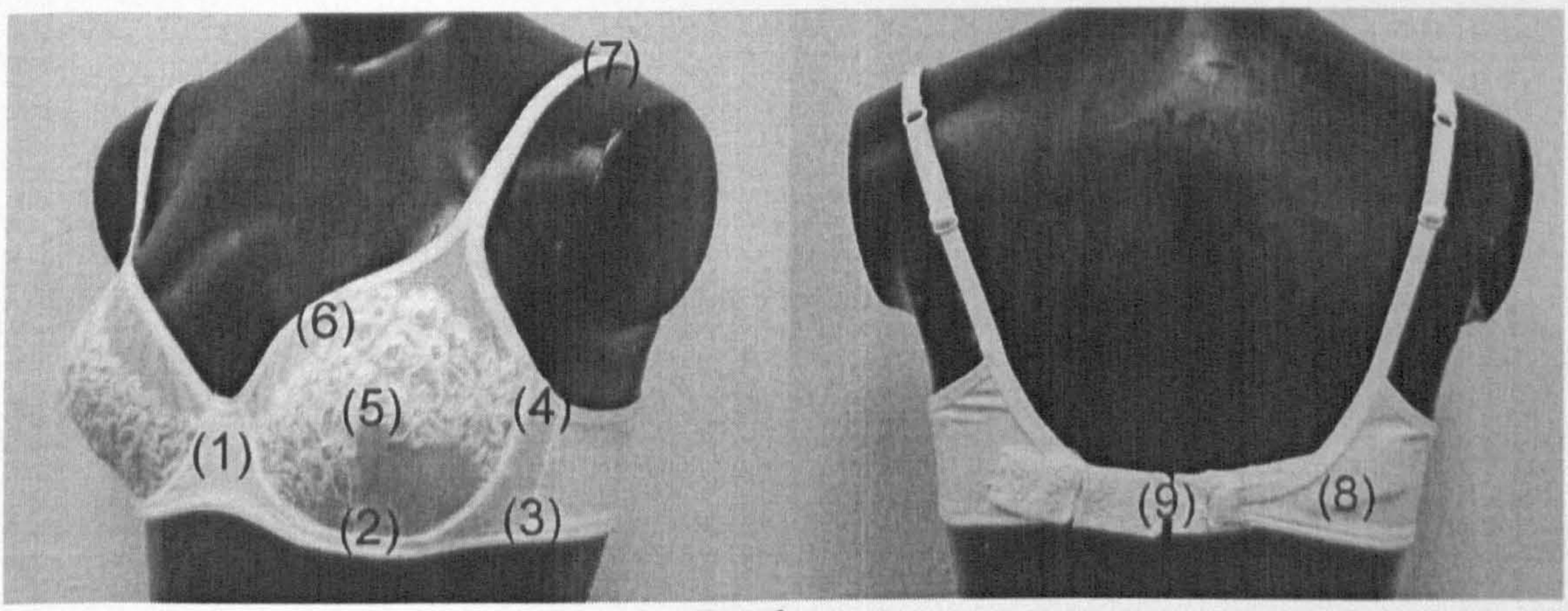
	Very strong	Strong	average	light	Very light	none
The DISCOMFORT in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The DISCOMFORT in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

Q.25. Do you think which of the following FACTORS can influence the discomfort sensation of the bra?

☐ Don't know
☐ The fabric
☐ The seam
☐ The wire
☐ The padding material
☐ Others, please specify _____

Q.26. Do you experience any PAIN when you are wearing a bra during your daily life?

☐ No
☐ Yes, can you select an option that best describes the level of pain in the following areas of the bra (The areas showed in Figure)?



Focal areas

	Very severe	Severe	average	light	Very light	none
The PAIN occurs in the area 1 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 2 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 3 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 4 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 5 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 6 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 7 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 8 of the bra is	☐	☐	☐	☐	☐	☐
The PAIN occurs in the area 9 of the bra is	☐	☐	☐	☐	☐	☐

(The End)

Thanks a lot for your assistance.

Appendix C: Questionnaire used in the survey (Chinese Version)

编号：_____ 日期：_____

女性胸罩压力与舒适性问卷调查

这份有关女性胸罩的问卷调查是博士研究生课题的一部分。请花几分钟时间回答下列问题，表达您的胸罩穿着习惯，对胸罩的评价以及您穿着胸罩的感觉。您的信息对于本课题的研究将产生非常重要的作用。

谢谢您的参与与协助。

第一部分：个人情况问题，这些信息将被用来研究是否不同的人对待胸罩有不同的态度。所有的信息都将是保密的。

Q.1. 您的年龄？

- ☐ 16 岁以下（调查结束）
- ☐ 16-20
- ☐ 21-25
- ☐ 26-30
- ☐ 31-35
- ☐ 36-40
- ☐ 40-45
- ☐ 46-50
- ☐ 51-55
- ☐ 56-60
- ☐ 61 岁及 61 岁以上

Q.2. 您的身高？_____ 厘米

Q.3. 您的体重？_____ 公斤

Q.4. 您的种族？

☐ 中国人

☐ 其他，请指明 _____

第二部分：胸罩穿着习惯问题

Q.5. 您在日常生活中穿着胸罩吗？请选择一个最接近您胸罩穿着习惯的选项。

☐ 全天穿着胸罩，包括睡觉时间

☐ 除了睡觉时间，其它时间都穿着胸罩

☐ 只在出外工作或离开家的时间穿着胸罩

☐ 只在一些特殊的场合穿着胸罩

☐ 只是偶尔穿着胸罩

☐ 从来都不穿着胸罩（调查结束）

☐ 其他，请指明 _____

Q.6. 您一天穿着胸罩的时间大约是多少小时？

大约 _____ 小时

Q.7. 您从多大年纪开始穿着胸罩？

大约 _____ 岁

Q.8. 您的胸罩尺寸是多少？

胸围尺寸：

☐ 65
☐ 70
☐ 75
☐ 80
☐ 85
☐ 90
☐ 95
☐ 100
☐ 105
☐ 110 以上，请指明 _____

罩杯尺寸：

☐ AA
☐ A
☐ B
☐ C
☐ D
☐ DD
☐ E
☐ F
☐ G
☐ G 以上，请指明 _____

Q.9. 您大约拥有多少件胸罩？

☐ 0-5

☐ 6-10
☐ 11-15
☐ 16-20
☐ 21 件及以上，请指明 _____

Q.10. 您去年大约得到了多少件新胸罩？（包括自己购买和朋友赠送）

☐ 0
☐ 1-2
☐ 3-5
☐ 6-8
☐ 9-12
☐ 13-15
☐ 16 件及以上，请指明 _____

Q.11. 平均来说，从一件胸罩的第一次穿着算起，您大约多长时间丢弃一件胸罩？

☐ 一个月之内
☐ 2-3 个月
☐ 4-6 个月
☐ 7-9 个月
☐ 9-12 个月
☐ 1-1.5 年
☐ 1.5-2 年
☐ 2 年以上

Q.12. 您在做运动时穿着胸罩吗？

☐ 是

您在做运动时穿着哪种胸罩？

☐ 和平时穿着的胸罩一样
☐ 专门的运动胸罩
☐ 只是在做剧烈运动时穿着运动胸罩
☐ 其他，请指明_____

☐ 否

您能说明原因吗？

☐ 我喜欢在运动中穿着紧身背心。
☐ 当我做运动时，胸罩会让我觉得不舒服。
☐ 其他，请指明 _____

Q.13. 您是否曾经经历过与乳房有关的健康问题？

☐ 否
☐ 是

这些问题有没有影响到您对胸罩的选择，胸罩的穿着习惯等与胸罩有关的事情？

☐ 否

☐ 是，您能说明是如何影响的吗？_____

Q.14. 您曾经穿着过不同尺寸的胸罩吗？

☐ 否，我一直只是穿着同一尺寸的胸罩。

☐ 是

您为什么穿着不同尺寸的胸罩？（多项选择）

☐ 由于不同款式，品牌之间的微小的尺寸差别

☐ 由于体形和体重的改变

☐ 由于怀孕

☐ 由于乳房手术

☐ 其他，请指明 _____

第三部分：有关胸罩的评价问题

Q.15. 对于下列有关胸罩的一些表述，请选择您对这些表述支持或不支持的强烈程度。

	强烈支持	支持	中性	不支持	强烈不支持	不清楚
对女性来说，胸罩是一种重要的服饰。	☐	☐	☐	☐	☐	☐
对女性来说，胸罩是一种必须的服饰。	☐	☐	☐	☐	☐	☐
对女性来说，胸罩是一种有益的服饰。	☐	☐	☐	☐	☐	☐
胸罩能够改善胸部的外形。	☐	☐	☐	☐	☐	☐
一些胸罩会破坏胸部的外形。	☐	☐	☐	☐	☐	☐
越紧的胸罩越能改善胸部的外形。	☐	☐	☐	☐	☐	☐
我认为不穿着胸罩外形更自然，更舒适。	☐	☐	☐	☐	☐	☐
我倾向于不穿着胸罩。	☐	☐	☐	☐	☐	☐
我穿着胸罩仅仅是尊重社交礼仪，否则，我更倾向于不穿着胸罩。	☐	☐	☐	☐	☐	☐
胸罩能够为乳房提供支撑。	☐	☐	☐	☐	☐	☐
穿着胸罩更舒服。	☐	☐	☐	☐	☐	☐
我情愿牺牲一些舒适性来提高胸罩对乳房的支撑性	☐	☐	☐	☐	☐	☐

和矫形性。						
我很乐意使用一些非纺织品材料，诸如化学聚合物或橡胶来提高胸罩对乳房的支撑性和矫形性。	☐	☐	☐	☐	☐	☐

Q.16. 您认为穿着胸罩会增大还是减少发生乳房健康问题的几率？

☐ 我认为穿着胸罩会增大发生乳房健康问题的几率。
☐ 我认为穿着胸罩会减少发生乳房健康问题的几率。
☐ 我不关心穿着胸罩是否会增大还是减少发生乳房健康问题的几率。
☐ 不清楚

Q.17. 您喜欢哪种款式的胸罩？（多项选择）

☐ 无衬垫，有钢圈的胸罩
☐ 有衬垫，有钢圈的胸罩
☐ 无衬垫，无钢圈的胸罩
☐ 有衬垫，无钢圈的胸罩
☐ Balcony bra
☐ 推挤，提升式魔术胸罩
☐ 无肩带胸罩
☐ 无缝合，一次成型罩杯胸罩
☐ T 恤衫式胸罩
☐ 其他，请指明 _____

Q.18. 从胸罩对乳房的支撑来说，您喜欢哪种程度的支撑？

☐ 完全的支撑
☐ 中度的支撑
☐ 轻度的支撑

Q.19. 下列是胸罩的一些特性，您认为哪个特性最重要，哪个特性最不重要？请将这些特性按从最重要到最不重要的顺序，用数字排列起来。

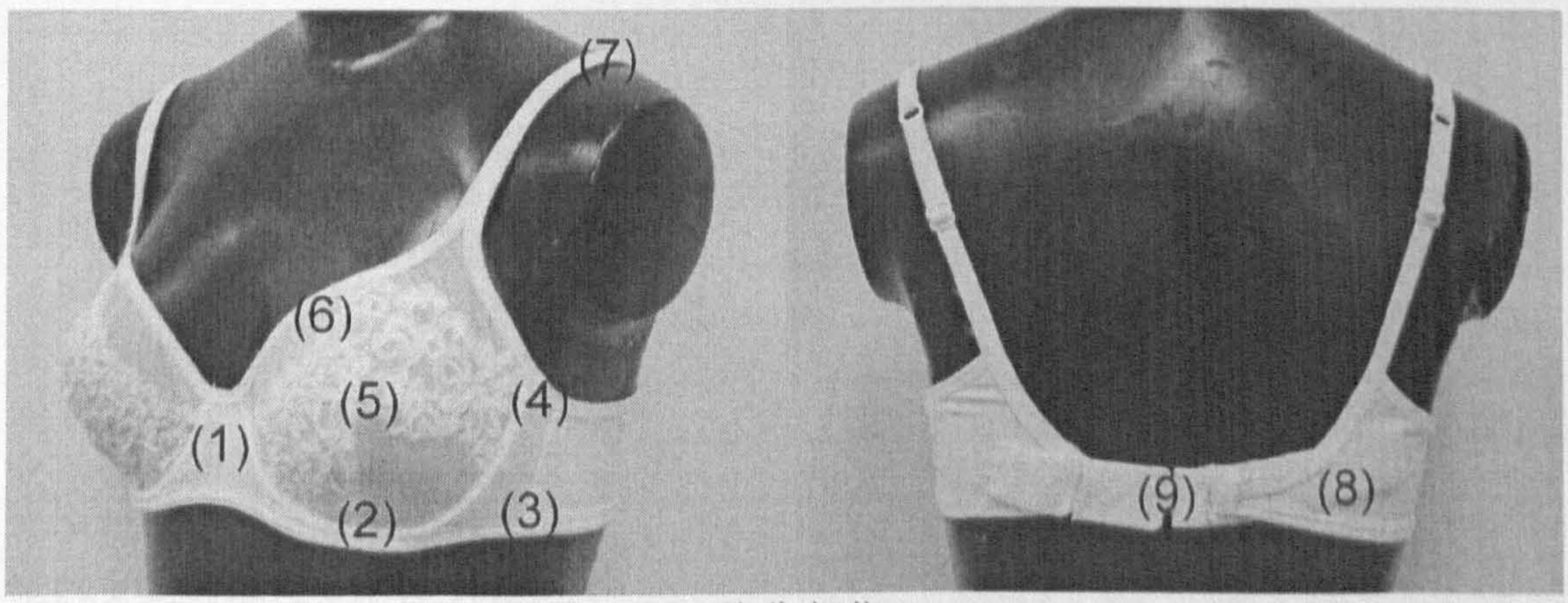
1. 合体性
2. 舒适性
3. 品质
4. 材料
5. 对乳房的支撑性
6. 价格
7. 品牌
8. 款式
9. 颜色

Q.20. 您是否对现在市场上所能购买到的胸罩产品满意？

☐ 是
☐ 否，请说明原因（多项选择）
☐ 我找不到适合我的尺寸。
☐ 我对市场上胸罩产品的舒适性不满意。
☐ 我对市场上胸罩产品的品质不满意。
☐ 市场上胸罩产品不能对我的乳房提供足够的支撑。
☐ 我对市场上胸罩产品使用的材料不满意。
☐ 我对市场上胸罩产品的款式不满意。
☐ 我对市场上胸罩产品的颜色不满意。
☐ 其他，请指明 _____

Q.21. 您总能在市场上购买到适合您的胸罩吗？

☐ 是
☐ 否，请根据下图选择胸罩的哪个部位最难适合您胸部的形状。（多项选择）

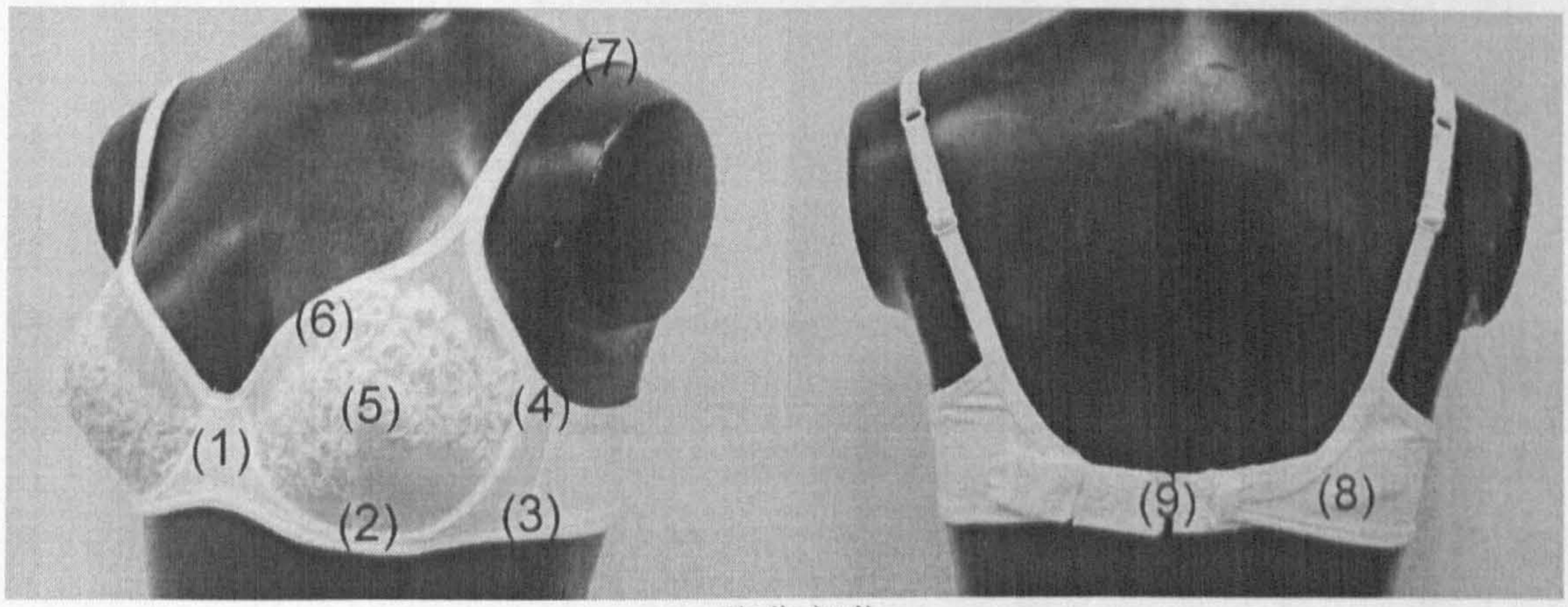


聚焦部位

☐ 部位 1
☐ 部位 2
☐ 部位 3
☐ 部位 4
☐ 部位 5
☐ 部位 6
☐ 部位 7
☐ 部位 8
☐ 部位 9

第四部分：胸罩的压力与舒适性问题。

Q.22. 根据您在日常生活中穿着胸罩时的感觉，请参照下图选择一个最接近描述您在胸罩的不同部位所感受到的对胸部压力程度的选项。



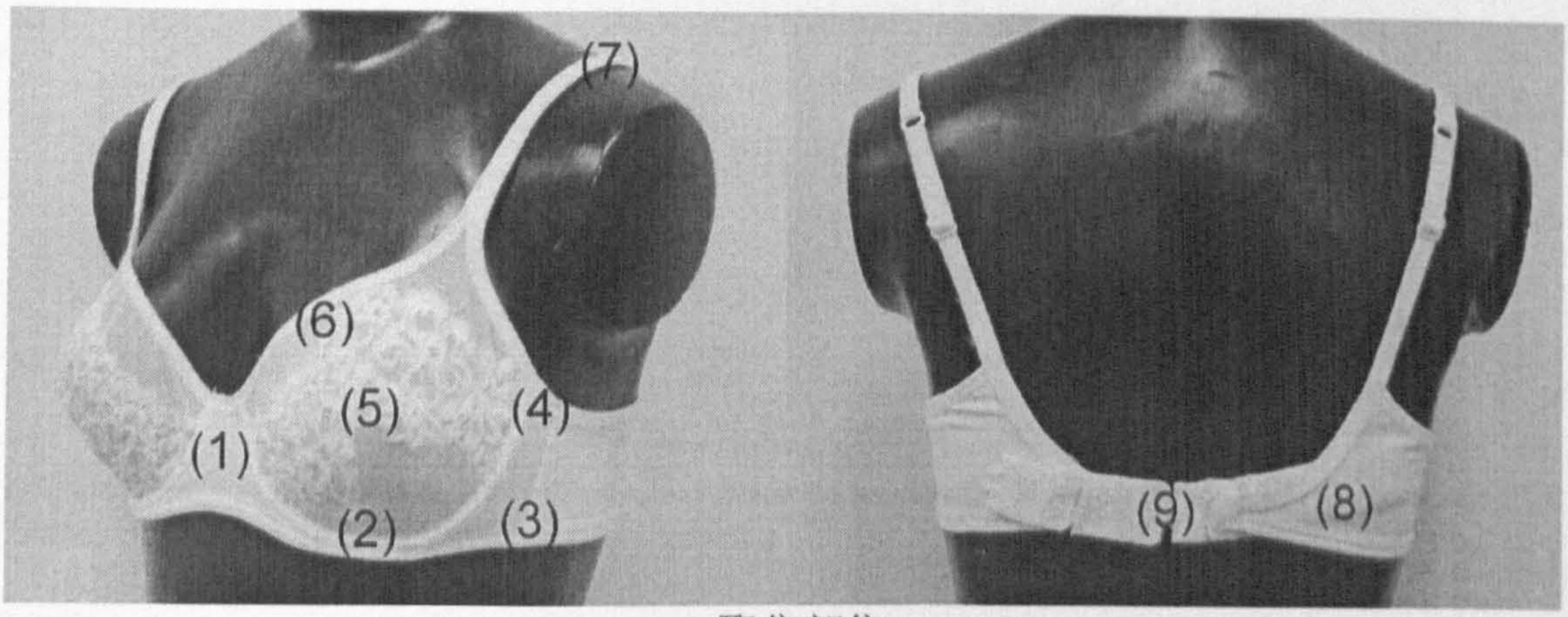
聚焦部位

	□非常强烈	□强烈	□一般	□轻微	□非常轻微	□无
我感受到的部位 1 的压力是	□	□	□	□	□	□
我感受到的部位 2 的压力是	□	□	□	□	□	□
我感受到的部位 3 的压力是	□	□	□	□	□	□
我感受到的部位 4 的压力是	□	□	□	□	□	□
我感受到的部位 5 的压力是	□	□	□	□	□	□
我感受到的部位 6 的压力是	□	□	□	□	□	□
我感受到的部位 7 的压力是	□	□	□	□	□	□
我感受到的部位 8 的压力是	□	□	□	□	□	□
我感受到的部位 9 的压力是	□	□	□	□	□	□

Q.23. 有些女性穿着胸罩时经历过不舒适的感觉，您认为不舒适的感觉都是由于胸罩对胸部的压力引起的吗？也就是说，您认为由胸罩引起的压力感觉和不舒适的感觉是一样的吗？

□ 是（跳至 Q.25）
□ 否（跳至 Q.24）

Q.24. 参照下图，请选择一个最接近描述您在胸罩的不同部位所感受到的不舒适性程度的选项。



聚焦部位

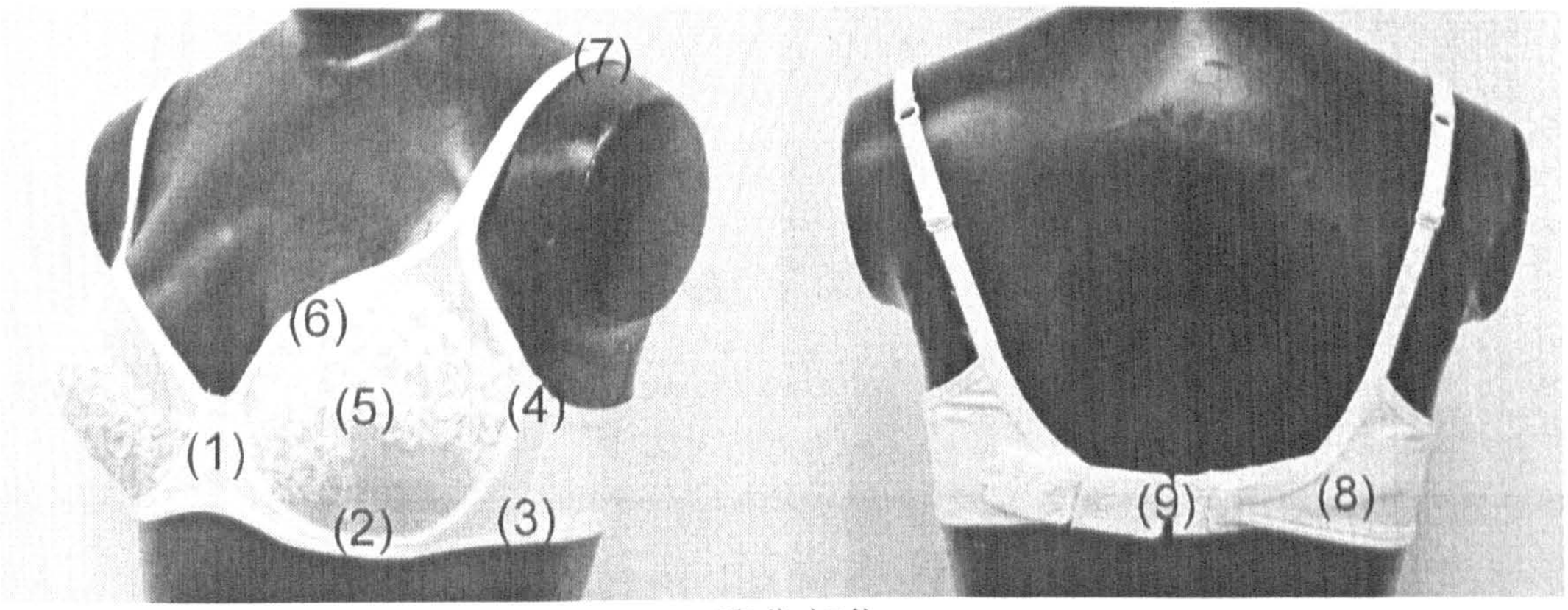
	非常强烈	强烈	一般	轻微	非常轻微	无
我感受到的部位 1 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 2 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 3 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 4 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 5 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 6 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 7 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 8 的不舒适性是	☐	☐	☐	☐	☐	☐
我感受到的部位 9 的不舒适性是	☐	☐	☐	☐	☐	☐

Q.25. 您认为下列哪些因素会影响胸罩的不舒适性？（多项选择）

☐ 不清楚
☐ 布料
☐ 接缝
☐ 钢圈
☐ 衬垫
☐ 其他，请指明 _____

Q.26. 当您在日常生活中穿着胸罩时，您是否经历过疼痛的感觉？

☐ 否
☐ 是，请选择一个最接近描述您在胸罩的不同部位所感受到的疼痛感觉程度的选项。



聚焦部位

	非常严重	严重	一般	轻微	非常轻微	无
我感受到的部位 1 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 2 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 3 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 4 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 5 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 6 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 7 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 8 的疼痛感觉是	□	□	□	□	□	□
我感受到的部位 9 的疼痛感觉是	□	□	□	□	□	□

（调查结束）

非常感谢您对本次调查的支持！

Appendix D: Survey record form

Survey Record

Group No.:

Time:

Place:

Respondents No.:

Total of respondents:

Total of effective questionnaires:

Group description:

Notes:

Appendix E: The registration form for the bra pressure and sensation tests

Registration Form of Bra Pressure Test

By PhD Student: Xiaomeng Liang (Mandy)
Supervisor: David Morris
Department: Contour Fashion

Time	Name	Bra size	E-mail	Mobil No.

Note: The information of bra size will be used to select a suitable bra for you in the test, the information of E-mail and mobile number will be used to send a reminder to you one or two days ago before the test.

Appendix F: The procedure and instructions for the bra pressure and sensation tests

Before the test:
Greet subject and thank for coming.
Explain stages of test procedure.

Step 1: Questionnaire
Equipment used: Pen, Printed questionnaire
Procedure: Ask subject to answer a questionnaire about women's bra.
Estimated time: 15 min

Step 2: Breast measurement and sample bra selection
Equipment used: Soft tape, pen, record paper
Procedure:
1. Breast measurement: Ask subject to undress her tops and bra, use a soft tape to measure:
Underbust: Stand in front of the subject, ask subject to lift her arms and correctly position the tape around the ribcage just below the breast root. The tape measure should be horizontally level all the way around and the subject should breathe normally. Ask the subject to lower her arms and then tighten the tape around the underbust, the measurement should be rounded down to the nearest full inch measurement.
Overbust: Stand in front of the subject, ask subject to lift her arms and correctly position the tape around the overbust, ask the subject to lower her arms, the overbust measurement should be generous, round up to the higher measurement.
2. Sample bra selection: Select a suitable sample bra for the subject to have a test.
Estimated time: 10 min

Step 3: Pressure test
Equipment used: Bra sensor, the sketch map of the test areas, pen, record paper
Procedure:
The pressure test is using a kind of pressure tester to test the pressure caused by bra. A sensor will be put between the breast skin and bra to test the pressure. It will not cause any

discomfort and harm, but during the test, there will be some touch by sensors and by hands to the breast, and in order to put the sensors in an accurate position, sometimes, naked breast will not be avoidable.

1. Ask subject to wear the sample bra.
2. Fasten the hook of bra into eye 1, which has a loosest wing length.
3. According to the sketch map, put the bra sensor specifically into the area 1, read the data of pressure and record. Repeat the same approach to area 2, until area 9.
4. Move the hook of bra into eye 2, repeat approach 3, until eye 10.
5. Test strap (Area 10) presure. Adjust the strap length from the loosest to the tightest. Repeat the step of 2, 3, 4.

Estimated time: 40 min

Step 4: Sensation evaluation

Equipment used: The sketch map of the test areas, the form of Borg CR10 Scale and the instruction of how to use it, pen, record paper

Procedure:

The sensation evaluation test is a survey of comfort sensation, you will be asked about your sensation of the bra, and a detailed instruction about the test will be presented to you before the test.

1. Ask subject to wear the sample bra.
2. Test pressure sensation. Fasten the hook of bra into eye 1, which has a loosest wing length. According to Borg CR10 Scale, Ask subject to select the number that best describes the amount of PRESSURE or TIGHTNESS she feel in the bra from area 1 to arca 9, record the number. Repeat the same approach to eye 2, until eye10.
3. Test discomfort sensation. Fasten the hook of bra into eye 1, which has a loosest wing length. According to Borg CR10 Scale, Ask subject to select the number that best describes the amount of DISCOMFORT she feel in the bra from area 1 to area 9, record the number. Repeat the same approach to eye 2, until eye10.
4. Test pain sensation. Fasten the hook of bra into eye 1, which has a loosest wing length. According to Borg CR10 Scale, Ask subject to select the number that best describes the amount of PAIN she feel in the bra from area 1 to area 9, record the number. Repeat the same approach to eye 2, until eye10.
5. Test strap (Area 10) sensation. Adjust the strap length from the loosest to the tightest. Repeat the step of 2, 3, 4.

Estimated time: 20 min

Step 5: Photo taking

Equipment used: Digital camera

Procedure: If the subject doesn't mind, the photos of below the neck and above the waist should be taken. In every wing length, three photos of face, side and back should be taken.

Estimated time: 20 min

After the test:

Thank subject for her time and ensure she has all here things before she leave.

Appendix G: The test data record form

Date: Start Time: End Time:
Subject No: Underbust: Overbust:
Bra sample size:

Pressure measurement

Area / Length	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Pressure sensation test

Area / Length	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Date: Start Time: End Time:
Subject No: Underbust: Overbust:
Bra sample size:

Discomfort sensation test

Area / Length	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Pain sensation test

Area / Length	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Appendix H:Cluster group membership based on pressure sensations

Case Number	Cluster group	Distance
1	2	1.619
3	1	4.015
4	5	2.936
5	4	2.581
6	2	3.092
7	4	3.231
8	1	3.387
10	4	3.666
11	5	7.519
12	4	2.204
13	3	4.818
14	2	1.483
15	5	2.719
16	5	1.779
17	5	5.142
19	1	2.263
20	2	3.472
21	3	2.989
22	4	3.305
23	4	4.686
25	1	3.544
26	2	3.426
27	1	4.633
28	2	2.043
29	3	3.927
30	2	2.516
31	5	2.817
32	4	2.715
33	2	1.483
34	2	2.046
35	4	3.829
36	2	5.110
37	4	3.093
38	1	2.273
39	1	1.212
40	2	7.395
41	4	4.090
42	4	5.095
43	2	3.699
44	4	6.031
45	4	3.196
46	2	5.676
47	2	1.856
48	2	1.931
49	2	4.045
50	5	2.768
51	4	2.921
52	2	3.166
53	4	2.921
54	2	2.201
55	2	5.282
56	1	3.239
57	4	3.657
58	4	6.930
59	2	2.046
60	2	.975
62	2	.975
63	4	3.216
64	3	3.659
65	4	2.727
66	4	3.825
67	5	3.853
68	4	2.932
69	5	2.785
70	5	1.878
71	2	3.759
72	5	2.181
73	5	4.181
74	2	2.364
75	2	3.045
76	5	3.628
77	2	3.936
78	1	3.148
79	3	3.018
80	4	4.106
81	4	2.949
82	4	2.987
84	2	2.716
85	5	2.889

86	5	1.914		138	2	1.815					
87	4	3.536		139	2	2.280					
88	2	3.692		140	3	3.354					
89	3	3.080		141	2	1.711					
90	4	3.666		142	2	3.773					
91	4	3.439		144	3	2.627					
92	4	1.988		146	2	2.425					
93	4	3.462		149	5	5.053					
94	5	3.123		150	3	5.276					
95	2	1.414		151	2	2.356					
96	4	3.448		152	3	5.093					
98	2	2.265		153	2	3.227					
99	1	1.825		154	5	3.829					
100	1	2.018		155	1	3.130					
101	1	3.342		156	2	2.444					
102	2	2.078		157	1	2.450					
103	2	2.244		159	2	3.807					
104	3	3.931		160	1	6.579					
105	1	4.075		161	1	4.171					
106	5	2.427		162	2	5.453					
107	1	3.387		164	4	3.134					
108	2	4.438		165	4	3.305					
109	1	3.485		167	2	2.834					
110	5	6.236		168	4	2.949					
111	1	7.058		169	5	4.490					
112	4	3.246		170	5	4.137					
113	4	5.931		171	1	4.890					
114	2	1.483		172	5	4.304					
115	5	3.259		173	2	4.189					
116	5	4.727		174	2	3.494					
117	4	3.966		176	2	7.504					
118	2	3.015		179	4	6.213					
119	3	5.919		180	4	3.617					
120	4	2.569		181	5	5.623					
121	2	4.485		182	3	3.587					
123	1	3.755		183	3	3.663					
125	2	1.483		184	1	3.148					
126	1	2.469		187	3	4.814					
127	2	1.979		188	1	2.870					
128	5	3.181		189	2	1.483					
129	5	2.642		190	2	2.601					
130	2	1.483		192	2	8.157					
131	2	1.483		193	2	2.532					
132	4	2.233		194	2	1.483					
134	4	2.894		195	2	4.448					
135	1	4.676		196	2	1.310					
136	1	3.148		197	1	4.552					

198	1	3.148
199	1	3.148
200	2	1.483
201	4	4.184
202	4	3.305
203	4	2.114
206	1	3.758
207	3	7.977
208	1	1.844
209	4	2.976
210	4	3.067
211	1	5.595
213	4	2.894
214	2	2.509
217	1	3.613
218	4	2.479
219	2	3.315
220	3	4.061
221	2	4.157
222	2	4.872
223	1	3.356
224	2	2.425
225	4	4.066
227	4	2.998
228	1	3.148
229	4	5.040
230	5	2.582
231	1	5.060
232	4	7.557
233	2	2.648
234	2	5.874
235	4	5.920
236	4	2.921
237	2	2.701
238	2	2.557
239	3	3.281
240	5	4.521
241	2	5.810
242	4	3.019
243	5	5.238
244	2	4.528
245	1	4.314
246	2	4.227
247	5	3.986
249	1	2.771
251	3	4.450
252	2	1.483
253	5	4.541
255	1	1.869
257	2	1.483
258	2	1.483
259	2	6.022
260	5	5.849
261	5	2.232
262	4	3.917
263	3	3.291
265	2	6.133
266	5	6.122
267	3	3.829
268	5	3.348
269	1	3.564
270	1	3.054
271	5	2.599
272	5	4.170
273	4	3.913
274	4	3.917
275	5	6.427
276	3	3.500
277	4	5.396
278	5	5.199
279	2	2.665
280	4	3.563
281	3	2.479
282	3	5.120
283	2	5.202
284	3	3.286
285	4	3.508
286	1	2.989
287	3	2.995
288	2	3.440
289	3	2.451
290	4	3.481
291	3	5.376
292	2	3.568
293	2	3.568
294	5	4.827
295	2	3.027
296	5	2.668
297	3	3.733
298	5	4.409

Appendix I: Cluster group membership based on discomfort sensation

Case Number	Cluster group	Distance
1	4	1.614
3	4	3.677
4	.	.
5	5	2.385
6	.	.
7	3	3.909
8	.	.
10	.	.
11	.	.
12	.	.
13	.	.
14	.	.
15	.	.
16	3	5.355
17	.	.
19	.	.
20	.	.
21	.	.
22	.	.
23	3	4.525
25	.	.
26	5	2.137
27	.	.
28	.	.
29	.	.
30	.	.
31	.	.
32	.	.
33	3	2.980
34	.	.
35	.	.
36	.	.
37	.	.
38	.	.
39	.	.
40	.	.
41	1	3.848
42	1	2.638
43	.	.
44	4	1.963
45	.	.
46	.	.
47	3	2.789
48	.	.
49	.	.
50	4	5.134
51	.	.
52	4	1.920
53	.	.
54	.	.
55	.	.
56	.	.
57	.	.
58	2	4.350
59	.	.
60	.	.
62	.	.
63	.	.
64	.	.
65	3	4.264
66	5	3.419
67	.	.
68	2	5.599
69	.	.
70	.	.
71	.	.
72	4	6.747
73	.	.
74	5	3.287
75	.	.
76	.	.
77	3	4.047
78	.	.
79	.	.
80	.	.
81	3	2.565
82	.	.
84	.	.
85	.	.
86	.	.
87	.	.

88	.	.
89	.	.
90	5	2.137
91	3	3.475
92	1	4.887
93	5	2.070
94	3	3.029
95	.	.
96	.	.
98	.	.
99	.	.
100	4	2.184
101	.	.
102	.	.
103	.	.
104	5	7.341
105	.	.
106	.	.
107	.	.
108	5	3.360
109	.	.
110	.	.
111	.	.
112	.	.
113	.	.
114	5	2.174
115	.	.
116	2	6.496
117	4	1.984
118	5	3.067
119	.	.
120	.	.
121	.	.
123	.	.
125	.	.
126	.	.
127	.	.
128	.	.
129	.	.
130	.	.
131	.	.
132	.	.
134	3	3.388
135	4	4.304
136	4	2.602
138	.	.
139	.	.
140	.	.
141	4	4.390
142	.	.
144	.	.
146	1	2.941
149	.	.
150	4	5.134
151	5	2.418
152	4	5.599
153	.	.
154	.	.
155	3	2.753
156	.	.
157	.	.
159	.	.
160	.	.
161	4	3.072
162	.	.
164	.	.
165	5	3.573
167	.	.
168	.	.
169	2	3.788
170	.	.
171	.	.
172	5	4.842
173	1	5.707
174	5	3.028
176	.	.
179	5	5.742
180	.	.
181	1	4.155
182	.	.
183	.	.
184	.	.
187	4	5.356
188	4	3.152
189	5	2.137
190	.	.
192	.	.
193	.	.
194	.	.
195	.	.
196	.	.
197	.	.
198	4	2.602
199	4	2.602

200	.	.
201	.	.
202	.	.
203	.	.
206	3	2.660
207	.	.
208	.	.
209	.	.
210	.	.
211	.	.
213	.	.
214	.	.
217	.	.
218	.	.
219	.	.
220	.	.
221	.	.
222	.	.
223	.	.
224	.	.
225	5	4.846
227	.	.
228	.	.
229	1	5.585
230	.	.
231	.	.
232	5	5.611
233	1	3.322
234	1	5.324
235	.	.
236	.	.
237	3	2.044
238	3	2.807
239	.	.
240	.	.
241	5	3.407
242	.	.
243	.	.
244	.	.
245	.	.
246	.	.
247	4	3.585
249	.	.
251	.	.
252	.	.
253	5	6.400
255	4	2.367
257	3	3.221
258	4	4.567
259	1	5.080
260	1	5.080
261	.	.
262	.	.
263	.	.
265	1	5.522
266	3	4.773
267	.	.
268	.	.
269	3	3.546
270	3	3.818
271	4	2.259
272	1	3.838
273	5	2.220
274	.	.
275	.	.
276	.	.
277	.	.
278	5	2.844
279	.	.
280	.	.
281	5	3.656
282	.	.
283	2	4.697
284	.	.
285	5	3.360
286	2	3.881
287	.	.
288	.	.
289	.	.
290	4	3.455
291	3	6.122
292	.	.
293	5	3.312
294	4	3.003
295	.	.
296	2	4.963
297	.	.
298	.	.

Appendix I: Cluster group membership based on pain sensation

Case Number	Cluster group	Distance
1	.	.
3	.	.
4	.	.
5	.	.
6	.	.
7	.	.
8	1	1.938
10	.	.
11	3	2.891
12	1	3.324
13	1	1.953
14	.	.
15	2	2.884
16	.	.
17	.	.
19	.	.
20	.	.
21	1	1.763
22	1	2.324
23	.	.
25	1	2.858
26	.	.
27	.	.
28	.	.
29	.	.
30	1	1.953
31	.	.
32	.	.
33	.	.
34	.	.
35	.	.
36	.	.
37	1	3.480
38	.	.
39	.	.
40	1	3.480
41	1	5.246
42	.	.
43	.	.
44	.	.
45	1	2.399
46	2	3.914
47	.	.
48	.	.
49	.	.
50	.	.
51	3	5.808
52	1	2.112
53	.	.
54	.	.
55	.	.
56	.	.
57	.	.
58	.	.
59	.	.
60	.	.
62	.	.
63	.	.
64	.	.
65	.	.
66	1	2.929
67	.	.
68	.	.
69	.	.
70	.	.
71	.	.
72	.	.
73	.	.
74	.	.
75	.	.
76	.	.
77	.	.
78	.	.
79	.	.
80	.	.
81	.	.
82	.	.
84	1	3.216
85	.	.

86	3	2.118
87	.	.
88	3	3.426
89	.	.
90	.	.
91	2	2.966
92	.	.
93	.	.
94	.	.
95	.	.
96	.	.
98	.	.
99	.	.
100	.	.
101	.	.
102	.	.
103	.	.
104	2	3.386
105	.	.
106	.	.
107	.	.
108	2	6.788
109	.	.
110	3	3.967
111	3	2.891
112	.	.
113	.	.
114	.	.
115	.	.
116	3	3.352
117	.	.
118	.	.
119	.	.
120	.	.
121	.	.
123	.	.
125	.	.
126	.	.
127	.	.
128	.	.
129	.	.
130	.	.
131	.	.
132	3	3.140
134	1	4.813
135	.	.
136	.	.
138	.	.
139	.	.
140	.	.
141	.	.
142	.	.
144	1	3.047
146	.	.
149	3	3.998
150	.	.
151	2	2.893
152	1	4.874
153	1	4.290
154	.	.
155	3	2.891
156	.	.
157	.	.
159	.	.
160	.	.
161	.	.
162	.	.
164	.	.
165	.	.
167	.	.
168	.	.
169	.	.
170	.	.
171	.	.
172	.	.
173	1	4.904
174	1	3.105
176	2	5.723
179	.	.
180	.	.
181	1	5.384
182	.	.
183	.	.
184	.	.
187	.	.
188	.	.
189	.	.
190	.	.
192	1	4.904
193	.	.
194	.	.
195	.	.
196	.	.
197	.	.

198	.	.
199	.	.
200	.	.
201	.	.
202	.	.
203	.	.
206	.	.
207	1	6.557
208	.	.
209	.	.
210	.	.
211	.	.
213	.	.
214	2	2.179
217	.	.
218	2	4.173
219	.	.
220	1	7.243
221	.	.
222	2	4.744
223	.	.
224	.	.
225	.	.
227	.	.
228	.	.
229	1	4.338
230	2	3.637
231	.	.
232	4	4.157
233	.	.
234	1	1.953
235	3	4.742
236	.	.
237	2	3.643
238	1	3.038
239	.	.
240	3	2.027
241	1	3.403
242	.	.
243	1	3.216
244	.	.
245	.	.
246	1	1.953
247	3	6.071
249	3	2.891
251	4	4.157
252	.	.
253	.	.
255	.	.
257	.	.
258	1	3.152
259	.	.
260	1	5.138
261	.	.
262	2	4.714
263	.	.
265	4	3.617
266	3	5.158
267	1	4.874
268	2	2.998
269	.	.
270	.	.
271	.	.
272	2	4.385
273	.	.
274	.	.
275	4	4.825
276	.	.
277	2	4.363
278	2	3.350
279	2	1.936
280	4	2.163
281	2	2.347
282	2	3.115
283	.	.
284	1	1.953
285	.	.
286	.	.
287	.	.
288	2	3.517
289	.	.
290	.	.
291	.	.
292	.	.
293	.	.
294	.	.
295	.	.
296	3	2.446
297	.	.
298	.	.